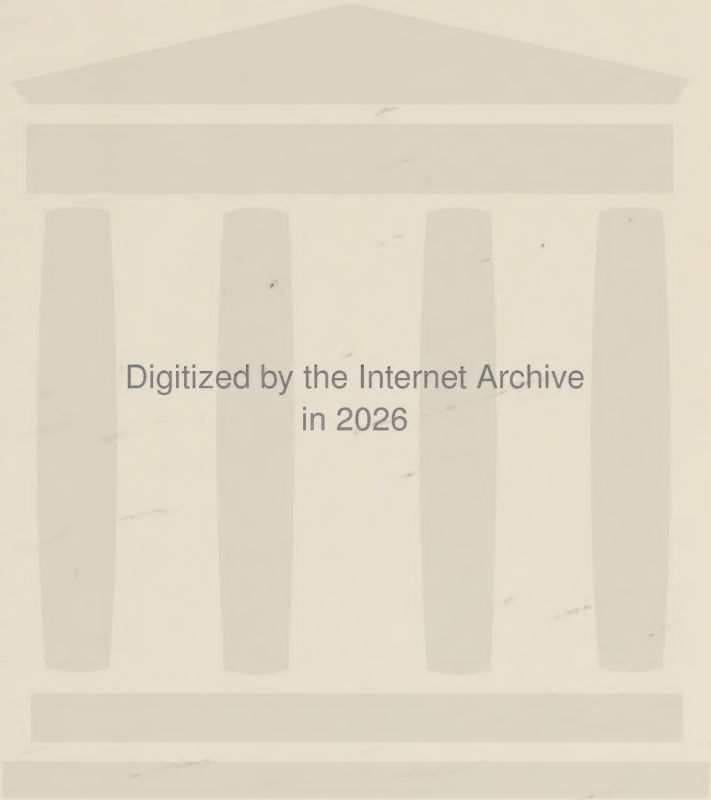
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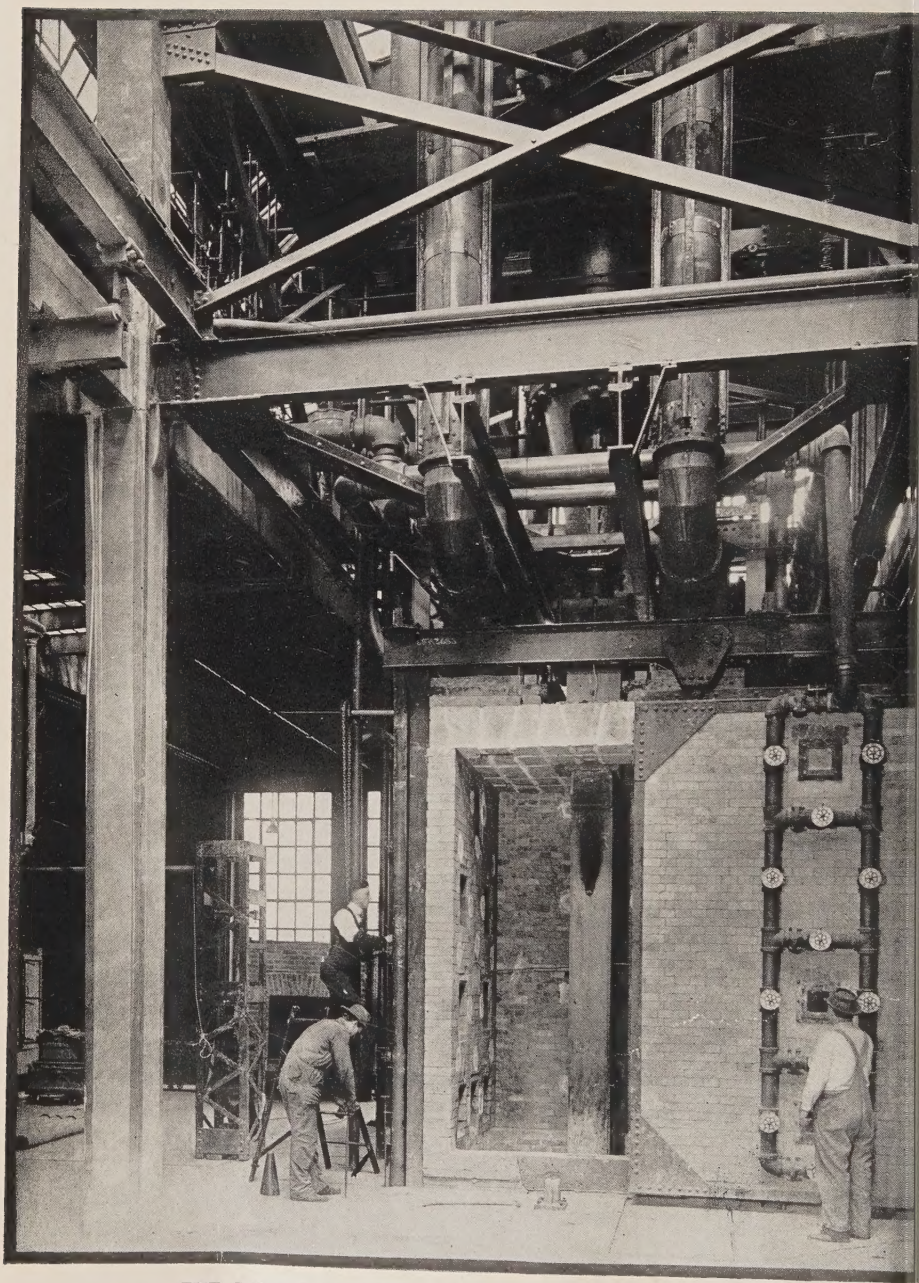
A SYMBOL OF SAFETY

PUBLISHER'S NOTE

This book is an account of the activities of Underwriters' Laboratories, Inc., an organization which pays no dividends and makes no profits, although it charges for its services, as explained in the text. The book describes the important way in which the work of this institution contributes to the safety of the public, and the publishers are happy to do all they can to encourage and endorse its activities.



THE GIGANTIC COMBINATION OF FURNACE AND RAM

In order to learn essential facts about the fire endurance of various types of columns, this unprecedented apparatus was constructed at a cost of many thousands of dollars. It consists of a furnace surmounted by a hydraulic ram of enormous power. Here is created a heat of the intensity of a conflagration, while, simultaneously, the ram exerts a downward thrust equal to the weight of many stories. The results of its use have been epoch-making in the structural industry. (See pp. 27-28, 83-87, 262-263)

A SYMBOL OF SAFETY

AN INTERPRETATIVE STUDY OF A NOTABLE INSTITUTION ORGANIZED FOR SERVICE—NOT PROFIT

BY

HARRY CHASE BREARLEY

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INTRODUCTION

LOOKING back over an eventful thirty years to the time when Underwriters' Laboratories consisted of one table, two chairs, and a few dollars' worth of simple electrical testing machines, it can be said that there was no suspicion in the mind of the one engineer who constituted the "force," that the institution would ever develop to anything like its present scope. Instead of this he merely was conscious of the task then in hand and was determined to make the required tests with all possible care, in a spirit of perfect fairness, and to express no opinion which was not first reviewed by competent field engineers working in separate territories.

Thus the work started not with a dream but with a purpose, which usually is the safest basis for a start. Ever since that first day this purpose has been steadily maintained, which is, I believe, the principal reason for all subsequent growth. For this reason, too, the growth of the institution has been solid.

If our work has expanded, it has been because of the expanding requirements of fields in which we are active. No new departments have been created and no new equipment has been added until the need for them has become clearly apparent. We have been too busy dealing with the practical problems of the present, to spend much time in speculating about the future. Of late years, however, there have been increasing indications that the work of Underwriters' Laboratories is coming to be regarded as having a significance far beyond anything that could originally have been believed—a significance that undoubtedly applies more to the future than to the past.

At the present time, Underwriters' Laboratories has grown into

remarkably wide and diverse relationships. Its connections run to many industries and to thousands of plants, as well as to many underwriting and technical organizations. It has been interesting to note the fundamental basis of common interest that exists among all these as regards our investigations and to realize that their interests and our interests are firmly bound up with the still larger interests of the general public. In the last analysis, it is the general public which is served by every activity of the institution.

Underwriters' Laboratories has been developed through the zeal and abilities of many devoted men. A few of these have passed on, but most of them, I am glad to say, are still with us. The spirit of rare harmony and enthusiasm which has prevailed has made it possible to consider the institution not as an *assemblage* of men and equipment, but as a distinct *organism*, which has grown up out of the ideals of the many who have built their lives into its activities. Its purpose has never been commercial, and the men who have contributed so freely of their best have lacked the incentives of purely personal ambition. With self-effacing devotion they have performed tasks the effect of which on public welfare is now seen to be incalculable. Any one who comes in contact with the real spirit of the institution will, I think, be impressed with the fact that it exists "for service, not profit."

The author of this book has been given every opportunity to make a study of the work of Underwriters' Laboratories, in order that he might convey an idea of its extent, diversity and significance, in so far as this is possible in a single volume. This is a story that never has been told, and I cannot doubt that a general understanding of our work will have a marked and helpful bearing on the development of its largest usefulness.

W. H. Merrill,
President, Underwriters' Laboratories, Inc.

CHAPTER ONE

Humanity and Hazard

IF HUMANITY had been content to leave things as it found them, men still would be naked savages, few in numbers, and exposed to the usual hazards of nature, such as storms, food shortage, and the attacks of wild beasts. Old age as we know it would be rare and violent deaths the rule. This is the situation today as regards a large part of the animal kingdom; for many thousands of years it must have been the only condition of life known to our early ancestors.

But, of course, these very earliest types are hardly to be considered men; they were really a kind of pre-human animal. *Man was not man until he began to meddle*, or, in other words, to seek to change the conditions that he found about him.

The chief motive for this activity was self-preservation, that is to say, the desire to escape from hazard. For ages its results were crude and bungling—rough shelters to protect from storms, skin clothing to resist the cold, primitive weapons for defense and also for use in hunting. In each case, at the start, these things must have been more or less accidental discoveries but they worked, after

a fashion, and there was something in the man brain that recognized their advantages and sought to improve them. Thus was established the principle of meddling with nature, or of *experimenting* as we like to call it. Out of it grew science and civilization.

Although in time civilization came to take account of many other things, hazard has remained always one of its largest concerns. The great human warfare against hazard is a remarkable story of changing conditions—of conditions that changed slowly at first but later with an ever-increasing speed.

Today we realize that much progress has been made. Violent deaths are now the exception; we are able to protect ourselves from storms; wild beasts are virtually conquered; the defense from cold has reached a point where men can face the rigors of a polar winter; the race has learned to produce food in quantity and to store it against a time of shortage and, as a practical result, millions now live in some degree of comfort where once there were only scattered groups all engaged in a day-by-day struggle for existence. This is one side of the picture.

But the picture has another side that is less reassuring. We have exchanged the few natural hazards of our early ancestors for a bewildering number of artificial dangers that have grown up with the progress of civilization. Everything today is on a vastly greater scale. Man-made towns are swept by conflagrations springing from

A ONE-QUART EXTINGUISHER AND A "STANDARD FIRE"

e efficiency of this omnipresent type of apparatus is of vital importance to the general public, hence, s made a subject of careful investigation. In the test here shown a "standard test fire" is produced h gasolene soaked cotton waste and, when burning fiercely, it is attacked with a one-quart extinguisher. One extinguisher must completely control the fire. (See pp. 59-63)

THE SERVICE TEST ON SPRINKLER HEADS

Guarding millions of human lives, automatic sprinklers receive a thorough scientific investigation at the Laboratories, as shown in several other photographs and explained in Chapter 8. But, as in the case of every other device, there must be a practical service test Here it is. The engineers call it the Distribution Test, to distinguish it from the Operation Test, which has to do with temperature and positiveness of operation. (See page 51)

man-caused fires. Man-made buildings collapse and bury scores. Man-made ships sink at sea and man-made trains crash in collision. Man's faithful servants: fire, steam, electricity and the processes of chemistry, which he has called forth from the realm of nature, frequently escape their bounds and work havoc. As the result of thousands of thousands of years of meddling with nature, man has thus exchanged the old natural world for a new and artificial world of tremendous potentialities and unnumbered perils. Thus new and complex hazards are by-products of science. If man is now surrounded by such a diversity of dangers it is needless to state that these have not been sought but have arisen unsought and sometimes unrecognized in the course of efforts to improve conditions of human life.

The history of science is one of splendid achievement. It is inspiring to realize that a two-legged animal with no natural tools but his ten fingers has been able to equip himself with powers that surpass in almost every respect those formerly imputed to gods and wizards. A man in a powerhouse throws a switch and a dark street, miles away, flashes instantly into brightness. An aviator springs into the air and clear across the Atlantic, from Newfoundland to Ireland, in a single day. The President delivers an oration in Arlington, Virginia, and every word, every inflection, is heard with the utmost distinctness by thousands in New York and in San Francisco. An au-

dience in comfortable theatre chairs climbs the peaks of the Andes, penetrates the jungles of Borneo or summons the world's most famous men to appear on the screen for its inspection.

The astronomer with his spectroscope is able to detect the composition of stars so distant that their light must travel for hundreds of years in order to reach us. The eye of the eagle and of the fly are so far surpassed by the telescope and the microscope that comparison is absurd. The engineer turns deserts into farms and orchards or opens a channel for ocean shipping through a range of mountains. The synthetic chemist improves on the materials of nature in more than one important instance.

In agriculture, commerce, industry and daily life the story is similar. Everyone is better fed, better housed and better dressed through the results of scientific research; quantity production now places within the reach of the poor such privileges that could not have been attained by the rich of a generation ago.

The inventive skill that applies the discoveries of science to human service is doubtless more active at present than in any previous time. At any moment, many thousands of men are deeply engrossed with models, at drawing-boards, or in laboratories seeking to perfect their devices and processes. An increasing stream of patents flows from the Patent Office. Great as have been the changes of the past few decades, those of the coming

generation bid fair to surpass them. The process of change appears to be steadily increasing its speed.

We have paid willing tribute to the magnificent achievements of science because the following pages must concern themselves more particularly with their attendant hazards. In so doing, we shall strive to sense something of the complexity of these hazards and their tremendous cost in life and property. We shall examine also the work of a remarkable institution that employs science to limit the destructiveness of science and to render her service to the race the subject of less apprehension.

We have already spoken of the man in the powerhouse with his potent switch. He is merely one of that great army of electrical operatives who have come into being because, in 1831, a scientist named Faraday inaugurated the Age of Electricity by his discovery of the principle upon which the dynamo is based. But Faraday probably had no suspicion that his interesting laboratory experiments were to make it possible for man to bring so incalculable a force into his daily service. There is no need to catalog the variety, extent and value of modern uses of electricity; they are too much a matter of our every-day life, but occasionally we feel the paralysis that falls upon a community when its electrical service is interrupted.

Indispensable as it is, however, the widening use of electricity has carried widening hazard; each year, its toll of life and property is formidable. Safeguarding and

protective methods are being made the subjects of constant study both inside and outside of the industry, as we shall later have occasion to note. Theoretically, it should be possible to free the use of electricity from hazard; practically, such an achievement seems to be far distant.

This is the age of other wonders besides electricity—gasolene, for example. Humanity called for an illuminant to replace the fast-disappearing whale-oil of two or three generations ago. Science found this illuminant in the newly-discovered petroleum deposits of Pennsylvania after it had been learned how to free the oil from certain by-products. One of these was a volatile fluid that seemed to have no special value except for cleaning until inventors realized that its dangerous explosive power could be used to drive machinery. Soon gasolene came into the daily use of millions of people. Thereupon, along with service, it brought a universal hazard of which our fathers knew nothing; it, also, has exacted a mounting toll of life and property.

There is a similar story to tell with regard to many other of the splendid, dangerous gifts of science. No sooner have we seized upon some new facility than we are likely to learn that nature may exact a serious price for its use.

One evidence of this is found in fire losses which, in the United States, *increased more than one thousand per cent.* between 1865 and 1922, while the population increased but two hundred per cent. A study of fire causes shows that a

large part of that loss can be traced to comparatively new devices and processes. The marked increase in loss of life and in bodily injury through accident is another result of material progress. Such things are inevitable but they are not necessary, which is merely a paradoxical way of stating that our swiftly-developing civilization thinks more of using than of safeguarding; they are inevitable only so long as this state of mind holds control.

CHAPTER TWO

The New Note of Precaution

THE eager search for new powers and new tools still is dominant but, rather recently, there has begun to be sounded a new note of precaution. Slowly, it is coming to be realized that material progress, like other things, is subject to the laws of economics and must not be purchased at too high a price. Conservation therefore is engaging an increasing amount of attention. It is already finding expression in many ways.

Among the most inspiring stories of the last few years are those that deal with great movements for conservation such as those for checking epidemics, utilizing waste, conserving the forests, limiting floods, preventing accidents and, in particular, that for combating the enormous losses from fire.

Fire prevention on any important scale is practically of the present century. For ages fire was regarded as a thing to be fought, not prevented, and attention was concentrated upon the training and equipping of fire departments, which, in America, with their constant opportunities for service, became famous for speed, skill and daring. Figuratively speaking, the American fire

alarm never is silent. Fifteen hundred fires each day means an average of more than one for every minute, night and day, 365 days in the year. When losses reach a yearly total of nearly half a billion dollars in absolute destruction, as has been the case, and when to this is added the distressing loss of thousands of human lives, it can be seen that even the efforts of the best-trained and best-equipped fire-fighters are not sufficient; it becomes imperative that an effort be made to limit the number of fires—to fight them before they break out.

Such considerations led at last to the inception of a movement that is among the most remarkable of the present generation—the great campaign of fire prevention. Originally promoted chiefly by the fire insurance interests, it soon grew into a nation-wide coöperation of individuals and organizations working by many methods, but to a common end. This is not the place to trace the history of this movement but a few of its achievements may be told.

Today in a number of states, all public schools are required by law to teach the rudiments of fire prevention to their pupils; Fire Prevention Day (October 9), proclaimed by the President of the United States and by the governors of the various states, is observed with appropriate exercises *of public instruction* in thousands of communities; building codes are being made increasingly rigorous; standards for electrical and other forms of in-

stallation have been worked out in great detail and widely promulgated; manufacturers are finding a growing market for safety appliances and the popular mind is becoming responsive as never before to the thought of protection from fire hazard. This is indicated by the large amount of attention now being devoted to the subject in newspapers and magazines and in meetings of business and civic organizations.

Many do not yet realize that fire prevention was *officially* enlisted in the service of the government during the World War and that it played an important rôle in many departments. All government properties engaged in war work were inspected and safeguarded by fire prevention engineers, and all new construction made large use of inspected materials and supplies. This was true in the case of camps, warehouses, navy yards, shipyards, terminals, docks and all other centres of war activity, where interruption by fire might have interfered with military efficiency. It was true also in the case of thousands of privately-owned plants engaged upon government contracts. In all these cases hazards were noted and suggestions made for their correction.

Such efforts met with general success. When one considers the high pressure of war production and transportation, with congested space, hastily-improvised facilities, inexperienced operatives, and the large handling of inflammables and explosives, the small proportion of fires

AT THE HELM SINCE 1893

Thirty years on the job and still happy. President Merrill's sense of humor has helped to bring him successfully through many trying situations

A MOMENTOUS MEETING OF THE BOARD OF DIRECTORS

The chairman of the board is seen signing a resolution just passed by the board at the

is noteworthy. Among the privately-owned plants, however, the recommendations of the fire-prevention engineers occasionally were neglected, sometimes with disastrous results. In one case, for example, the proprietors of an ammunition plant disregarded the safety instructions and the resulting fire and explosion destroyed millions of dollars' worth of munitions. Such exceptions merely prove the rule.

People who read the statistics of American fire loss often ask, "after all, does fire prevention prevent?" The answer of the war is unmistakable: fire prevention *does* prevent—when it is given a chance.

We are justified in regarding this whole question as the conflict of two contending forces.

Lined up on one hand are the vast combustibility of our millions of frame buildings and our square miles of wooden shingles; the national carelessness of an optimistic, progressive people, impatient of detail; the rapid growth of congested city life with its attendant fire hazard; the universal employment of electricity, gasolene and other modern utilities; the enormous increase in the use of cigarettes; and sundry other elements, including the evil torch of incendiarism.

Against these are arrayed the various factors of education, legislation and enforcement already indicated, and, recently summoned into combat, the mighty and resourceful hand of science.

"Fire possibilities exist on every hand; they are found in the most unthought-of places. It is natural to associate fire hazard with a box of matches but who would look for it in a glass of water? Yet potassium or sodium thrown into water bursts at once into flames, while a few drops of water on gray, rocklike calcium carbide produce acetylene gas. Many fires have been caused by water. Fire is continually originating in the most unexpected ways—by the spark from an accidental hammer blow in a room containing gasolene fumes, even by the well-meant action of a hospital nurse in oiling the body of a live-steam victim and covering him with blankets—in this case, spontaneous combustion cost the life of the patient.

"Invention is a constant hazard; new devices and processes are continually introducing elements of the greatest danger. The versatile but highly inflammable celluloid is a case in point. There is also a lacquer used in shoe manufacturing and known to the trade as 'dope'; it is prepared from celluloid scrap and its use in a wooden shed was the starting point of the thirteen-million-dollar Salem conflagration in 1914. The giant new industry of moving pictures was not generally supposed to be hazardous until disastrous fires and serious loss of life resulted from it. There is a well-recognized fire hazard in incubators, in curling-irons, in rain-coat manufacture, in various polishing, cleaning and sweeping compounds, and in countless other products and processes.

"With the daily use of fire for purposes of cooking, lighting, heating, commerce, industry, art, science or pleasure by almost every individual in every community; with sparks borne by the winds from smoke-stacks and chimneys; with barns and houses burned by lightning; with the omnipresent commercial electricity always ready to transform itself into fire through some defect in transmission, and with fire hazard lurking unseen in the incessant stream of devices emanating from the busy brains of our inventors, there can be small wonder that appalling destruction marks the pathway of man's most useful servant."

Thus, intentionally or unintentionally, fires are constantly being caused. Next they try to grow. The tiniest flame is ambitious to become a conflagration and will do so if it have the chance. It is a common saying among fire-fighters that the *first five minutes* at a fire are more important than the next five hours. Fanned by a strong wind fires sometimes spread with such speed that people have been run down by flames in the open. The spread of fire is a question of combustible conditions, and these will be discussed in the following pages, notably in the chapter on building materials. However, one fact must not be overlooked in considering either cause or spread—*at every phase of its existence, Fire is subject to natural laws.* There is nothing truly mysterious about it; it is a proper subject for scientific study. It is perfectly possible to learn

all the ways in which fire may be caused and so to learn how *not* to cause it; it also is practicable to determine the factors governing the spread of fire and to use this knowledge in preventing the spread. Thus fire prevention and fire resistance on their physical side are strictly matters of applied science.

It is for this reason that Underwriters' Laboratories originally came into existence although its work has now grown, naturally and logically, to include the fields of accident and burglary prevention and automobile and aeronautic safety as well.

CHAPTER FOUR

The Genesis of Underwriters' Laboratories

LIKE many other important influences of American life, Underwriters' Laboratories was, in a way, an outgrowth of the World's Fair of 1893. This great exposition, which gave a pronounced impetus to American architecture, which opened the eyes of the public to the coming dominance of electricity, which exerted a profound influence on manufacture, transportation, mechanics and art, and which, perhaps, first taught the American people to think in international terms, also furnished an opportunity for the germ of a protective idea to take root and begin to grow.

In 1893, William H. Merrill came to Chicago to serve as an electrician of the Chicago Underwriters' Association, his special task being that of solving some problems in connection with automatic fire-alarm service in Chicago and of inspecting the electrical installations at the World's Fair, which were altogether unprecedented in scope and importance. He brought with him the laboratory idea that was later to germinate. This he had suggested to the Boston Board of Fire Underwriters before coming to Chicago, but they had not felt warranted in authorizing

its establishment. In Chicago, however, certain tests became necessary and a small room was taken on the third floor of Fire Insurance Patrol Station No. 1 on Monroe Street. Here, above the horses of the salvage corps, were installed a bench, a table, some electrical measuring instruments and a few chairs, the whole "plant" representing an investment of about $350. The staff consisted of Mr. Merrill, one helper and a clerk.

Thus began an activity which in thirty years has grown to embrace the services of two hundred engineers and other inside employés, 250 outside inspectors, a plant containing fifty-five thousand square feet of floor space in Chicago,* and branch laboratories in New York and San Francisco, a Canadian organization under a Dominion charter, offices in 141 cities and a connection in London.

The original work, as already stated, was purely local but the principle of growth was in the germ and it soon was extended to embrace the territory of the Western Union—an insurance organization, not the historic telegraph company. It then assumed the name of the Underwriters' Electrical Bureau, and operated under the auspices of both the Western Union and the Chicago Board. It was not long before the quality of the work began to attract attention outside of its original territory. This, together with the reports issued on electrical fires and the inauguration of model report blanks, so favorably impressed the

*Work is about to begin on a 40,000 square foot addition to the Chicago plant.

A CONSULTATION IN THE PRESIDENT'S OFFICE

Officers and heads of departments are holding an interested discussion over a proposition that has been submitted by a member of the staff. Those shown from left to right are: Front row, L. B. Headen, Treasurer; A. R. Small, Vice-President; W. H. Merrill, President; D. B. Anderson, Secretary; Fitzhugh Taylor, Fire Protection Department; B. H. Glover, Department of Electricity and Signals; Back Row: R. W. Hendricks, Hydraulic Department; A. H. Nuckolls, Chemistry Department; C. R. D'Olive, Label Service; C. R. Alling, Casualty, Automotive and Burglary Protection Departments; E. J. Smith, Department of Gases and Oils; B. E. Blanchard, Assistant Secretary; G. T. Bunker, Assistant Secretary

FEELING THE PULSE OF THE ELECTRICAL INDUSTRY

National Board of Fire Underwriters that that body decided to make a small allowance to the Electrical Bureau which thereupon became recognized as the Electrical Bureau of the National Board and operated on a somewhat increased scale.

Then came a new impulse from an outside source that started development along a collateral line, as has been the case from time to time ever since.

The story has often been told of the engineer who, in 1892, while experimenting with an electrical furnace in a North Carolina town, failed to secure the results he sought but found in the furnace when it cooled a dark gray, brittle substance, then strange but now well known as calcium carbide. The engineer threw the apparently useless stuff into a stream and was astonished to see the water bubble vigorously from the generation of gas. Thus was discovered the valuable gas, acetylene, widely used today for illumination, welding and other purposes. Its obvious utility quickly led to the manufacture of crude generators which in turn showed a disconcerting tendency to explode and cause fires. Thereupon, insurance companies were forced to give them attention, and Mr. W. C. Robinson, then sprinkler inspector for the Chicago Underwriters' Association, was detailed to study this new hazard also under the auspices of the Union Committee. As this work required testing facilities, it seemed reasonable that the two lines of investigation be brought together and that the

committee's work be extended to include the whole field of fire protection and fire prevention engineering.

Presently it developed that similar work on acetylene was being carried on in Boston and in Atlanta, and conflicting reports began to appear. Consolidation was again "indicated," as the surgeons say, and the result was the formation of the Committee of Consulting Engineers of the National Board of Fire Underwriters and the concentration in Chicago of the testing work. This committee specialized in the hazards of heating and lighting as electrical work had been nationalized by the formation of the Underwriters' National Electric Association.

Now had come the time for much larger quarters and a two-story brick building, at 67 East Twenty-first Street, was selected. This building, which had served as a boys' school and gymnasium, and seemed spacious beyond all dreams of future need, was outgrown within a decade.

The next definite advance was in connection with the National Fire Protection Association, which body formed a Committee on Devices and Materials to work in the field of fire-protection appliances. There ensued a gradual development of personnel, facilities and range of operation. At no time was there any effort to grow but rather a concentration on the quality of the service to be rendered. The result was inevitable for the work won rapid recognition in electricity, acetylene, gasolene and other hazards and began also to be felt in the field of

protective appliances, hand fire extinguishers, fire doors and fire windows.

One of the contributing factors to this growth was the lack of uniformity in the opinions of others who were supposed to be expert in some of these fields. When the judgments of authorities differed it obviously was necessary that there be some court of last resort such as could be found only in an adequate laboratory, where tests could be made without previous bias and their results could be certified. Thus the work progressed quietly and steadily. From time to time, as required, new apparatus was secured and additional engineers, specialists in various branches of the testing, were drawn into the staff.

By November, 1901, the institution had outgrown the committee form of organization, and was incorporated as "Underwriters' Laboratories, Inc." under the laws of Illinois, the state granting a charter "to establish and maintain laboratories for the testing of appliances and to enter into contracts with the owners and manufacturers of such appliances respecting the recommendation thereof to insurance organizations."

The National Board of Fire Underwriters had become so deeply convinced of the value to the insurance business of the work of Underwriters' Laboratories that, in 1903, it made a general appropriation for the purpose of building up the institution along broader lines. It now became possible to secure a site on East Ohio Street and to erect

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a *really* fire-proof building as a home for the rapidly expanding activities and incidentally as a demonstration to architects and contractors of the possibilities of safety construction. This building was enlarged by successive additions until it extended over the entire 266 ft. of property frontage and, in 1923, reached a total floor space of 55,000 sq. ft. Later, some idea will be given of the unique aggregation of testing facilities thus created.

In 1906, there occurred another important extension of the Laboratories' work; this was the inauguration of a label service for the purpose of certifying the results of this work as it affected individual products. It involved a natural corollary of inspections at factories. This work, hereafter to be described, grew out of the need for aiding manufacturers to secure continued recognition of the safety standards once established through the test of their products. Naturally, this involved continued contacts and was received with great favor by the various industries affected. Therefore there grew up a staff of inspectors, operating from branch offices in sixty-eight different cities and visiting thousands of factories.

The most important of these branch offices is that in New York which passed under the charge of Vice-President Dana Pierce in 1912. Since then it has grown into an important testing station and the inspections made between Trenton, New Jersey, and Bridgeport, Connecticut, are all directed from this office.

This account touches but a few of the high spots in thirty years that naturally have been crowded with detail. However, it is difficult to draw the members of the Laboratories' staff into reminiscence. Their thoughts are little concerned with the past in comparison with the interests of the swiftly-expanding present and the indefinitely greater requirements of the future.

CHAPTER FIVE

The Home of the Laboratories

THE building at 207 East Ohio Street does not "look the part," at least to the layman. Fancy the disappointment of one whose imagination has been stirred by such expressions as "within its walls science is fighting the battle of civilization with fire," who has been told that materials are here given the fiery test of "artificial conflagration," who has thought of the vast uproar and confusion caused by human hazard in its many forms of fire, casualty and crime, and who has therefore visioned the place where these hazards are grappled with as something flaming and thunderous, something between a steel works and a cataclysm, when he finds—what? A long, low, "academic-looking" building of brown brick and terra cotta with no suggestion of a thrill in its many windows. It might be a school, it might be a library—almost anything but the scene of intensive scientific encounter that he knows it to be.

He goes inside and receives an impression of the quiet, busy intentness of many people at tasks whose meaning at first is not clear to him. He sees that some are engaged with reports and correspondence, while others are making

use of a great variety of apparatus to which they are giving absorbed attention, with frequent jottings on record blanks. Presently, however, this silent, orderly activity begins to inspire in him a new sense of values, and under the guidance of some one acquainted with the institution, he commences to understand.

There are long rows of offices opening from central hallways, there are benches where chemists stand before racks of jars and bottles and are busy with test tubes or bunsen burners. There are myriad electric devices and sundry stretching and straining machines. There is the long vista of the hydraulic laboratory, with its complication of pipes, valves and tanks. There is a succession of furnaces of various sizes and shapes, some of them with glowing mica peepholes, which speak of the intense fires that rage within.

Many other things there are, and, most impressive of all, perhaps, is the mighty column-testing apparatus whose installation has marked an epoch in structural engineering. Little noise is to be heard; there is no rushing about, nor, on the other hand, is there any sign of loitering, for each person is seen to be giving his entire attention steadily to the task in hand, although the nature of this task may not at first be clear to the visitor.

A very early impression is sure to be that the entire building is more than merely fire resistive. It actually is *fire-proof*, which is a term that rarely can be used with

accuracy. Indeed, it is doubtful whether any other important building in America is so nearly 100 per cent. in safety from fire hazard. An architect or a builder could spend considerable time profitably in studying the solution of this problem as here portrayed. He would see the way in which wood has been eliminated without loss of beauty, for some portions, particularly the spacious tile-lined office of the President, were designed to serve as object lessons in the possibility of combining attractiveness with safety. He would see how all vertical and horizontal openings have been safeguarded, so that even a "theoretical" fire could not go far; and then he would see what might appear like superfluous fussiness, namely, a full equipment of automatic sprinklers in the ceilings of the rooms. It is hardly to be expected that an occasion will ever arise that will call these sprinklers into action, but here again the purpose is largely that of an object lesson. In other words, Underwriters' Laboratories must practice what it preaches and adopt every provision for safety.

Mr. Kohlsaat, the famous journalist, in telling of his experience one night in a London hotel during a war-time air raid, says that he asked a chambermaid the next day why he had not been aroused and called to the basement for safety, as the hotel employés had been, and she answered artlessly: "Oh, but you are not under the Employer's Liability Act." The 170 members of the Laboratories' Chicago staff have the satisfaction of knowing that

their protection is more substantial even than that afforded by a "liability act".

Throughout the building, at numerous points, will be found many devices and materials undergoing test. Some of these tests have a touch of the spectacular, as, for example, that in which a mass of flames is hurled, under forced draft, against the surface of a sample of roofing; that of dropping a red-hot safe from the height of a third story upon a pile of bricks; or that of turning the full force of a fire stream upon the surface of a fire door that has been taken incandescent from the testing furnace.

On the other hand, the great majority of investigations are perfectly matter-of-fact in appearance and mean little to the layman without an explanation. Some of them will be discussed more fully in succeeding chapters. But there is one piece of apparatus already mentioned that is sure to capture the attention of any visitor, even though he may not see it in operation. This is the gigantic combination of furnace and hydraulic ram that is used in determining the qualities of columns.

Imagine a room seven feet square and twelve feet high, built up of heavy masonry and surmounted by a huge hydraulic ram that rears itself forty-five feet above—a ram of such enormous power that it might have pulled the building from its foundations, had not special foundations been constructed to support it. Within this room, on many occasions, there has been created a heat equal in

intensity to the most terrific conflagration, and, simultaneously, the ram has exerted a downward thrust equal to the weight of many stories. Some of the blackened and distorted columns that have been submitted to this ordeal are to be seen in the courtyard. Their appearance removes any doubt as to the thoroughness of the test.

The important work that takes place in the New York office of Underwriters' Laboratories must also be included in a general impression. This rapidly growing branch occupies two floors of its own building at No. 109 Leonard Street and now conducts something more than one-half of the total work done by the Laboratories in the examination and test of electrical and signal devices. This is largely due to the fact that a large proportion of the manufacturers of electrical goods are located in the East.

The New York office has an especially designed and very well-equipped testing house for short-circuit tests on fuses adjoining a sub-station of the New York Central Railroad at Kingsbridge in upper New York. At this sub-station facilities are provided for fuse tests by means of a very large storage battery with complete equipment of protective devices, instruments and the like, with which these important tests can be conducted rapidly and safely.

The laboratory equipment of the New York office includes many types of apparatus for electrical tests and also for certain of the tests of the Casualty, Automobile and Burglary Protection Departments.

A BUSY MORNING AT THE NEW YORK LABORATORY

Here is an actual battle scene in the war of science against the electrical hazards of modern civilization. It is in this room that many new electrical appliances receive their first examinations and tests with regard to their safety, reliability, mechanical strength and other features. The engineer in the foreground is calibrating one of the Laboratories' numerous voltmeters by means of a "potentiometer" and the one at the right is conducting an overload test on an ordinary key socket.

BUILDING AND DOCTORING THE LABORATORIES' EQUIPMENT

In testing thousands of different devices in ways not previously tried, it often is necessary for the Laboratories to invent its own testing apparatus, and to build it in its own well-equipped Plant Department. The machine shop is also called upon to maintain in perfect condition the thousands of pieces of electrical, physical, chemical and hydraulic testing apparatus at 207 East Ohio Street

Few visitors wish to make a quick passage through the various departments of the Chicago testing station, since the themes for interesting discussion so abound on every hand, and one readily comes to realize why and how this institution has become so central in the entire campaign for human safety. The lasting human impression is likely to be a composite memory of a smooth-faced, spectacled, youngish-looking man—a typical testing engineer—with a frown of concentration between his eyebrows, intent upon an indicator in the absorbing task of "finding out about something."

CHAPTER SIX

The Significance of the Label

WHEN it is stated that the annual output of the Underwriters' Laboratories' labels increased from fifty million for the year 1915, to fifty million per month in 1922, it is obvious that the label plays an important part in the affairs of the institution and is of vast significance to the public. What then is the label?

The label is a certificate of character awarded to an inanimate object. It is an epitome of the technical skill, costly equipment, wide experience and thoroughgoing methods of investigation that have been concentrated upon that object in the process of searching out its every point of weakness; it is, therefore, the one best means of bringing to the buyer and user the opinion he desires as to the merit of appliances.

Some of the chapters which follow will give a slight idea of the gruelling tests that often precede the award of the label, and explain the feeling of satisfaction with which thousands of manufacturers view its attainment. Like everything else connected with the institution, however, the label is entirely and intensely practical; its purpose is

as far as possible removed from sentiment, for it is concrete evidence to officials, inspectors, contractors, merchants and the general public that the labeled product has been awarded a recognized standing *in its relation to fire and accident hazards.*

Now the label is one of several forms of recognition of a device made or service rendered by a Laboratories' client, but it is the most important, and the best known. In several industries it has come about that it is the first thing looked for by prospective purchasers. One reason is that it does not only mean that samples of the goods have been tested *once,* but that year after year these goods must continue to maintain their quality, or they will forfeit their rights to the label.

"Are these goods approved?" asked several of the fifty-odd electrical dealers attending a Brooklyn auction early in 1922, as a case full of receptacles was put up. "Sure," was the glib reply, whereupon the bidding grew spirited and the lot brought ten dollars a hundred. Later the buyer discovered that the receptacles were not included in the Laboratories' Electrical List, and he became indignant. "You should have heard the storm of complaint," said a witness. "Most of those present were the cheapest kind of dealers, but even they knew the value of Laboratories' listing; the dumfounded auctioneer took back the box, put it up again, and the highest he could get was four dollars a hundred." The next item was

a lot of plug-type fuses. Someone asked if they were "standard," and again the ignorant auctioneer took a chance on saying "yes," whereupon the same thing happened, the public forcing the auctioneer to call off the sale.

This episode shows strikingly the value of Laboratories' listing to the jobber or dealer. But how about the manufacturer? Does he welcome the operation of the Label Service in his plant? A single instance will indicate.

The manufacturer in question has plants throughout the country, in twelve of which the Label Service was operated. He told the vice-president of the Laboratories that he had an excellent product and wanted to keep it so. These plants had received from him the most particular specifications as to design, construction, and inspections. He felt that his requirements were even stricter than those of the Laboratories. Under these conditions the visits of the Laboratories' inspectors seemed to him superfluous.

However, such visits were a condition of the use of the label and the inspectors as usual took nothing for granted. To the manufacturer's amazement, they found that his admirable instructions were disregarded, that in certain plants the test methods and apparatus did not conform to the established standards laid down by him, that not one of his own inspectors was rejecting defective products, and so on. This revelation brought about a shake-up, and it took three years for every needed change to be effected; but today the manufacturer belongs to the

growing class who *use the Label Service for their own benefit*, for the sake of their reputation, as a check upon their own inspectors, as a means of maintaining their policy covering their product, as a tonic to their production departments, and as a good influence on *esprit de corps* in their own forces—quite regardless of the sales value of Laboratories' listing.

However, the significance of the label goes far beyond its value to manufacturers. Underwriters' Laboratories was established by the insurance companies for purposes of pure self-interest; it is primarily a servant of underwriting, and the way in which it also has become a servant of industry and of the public is an interesting story.

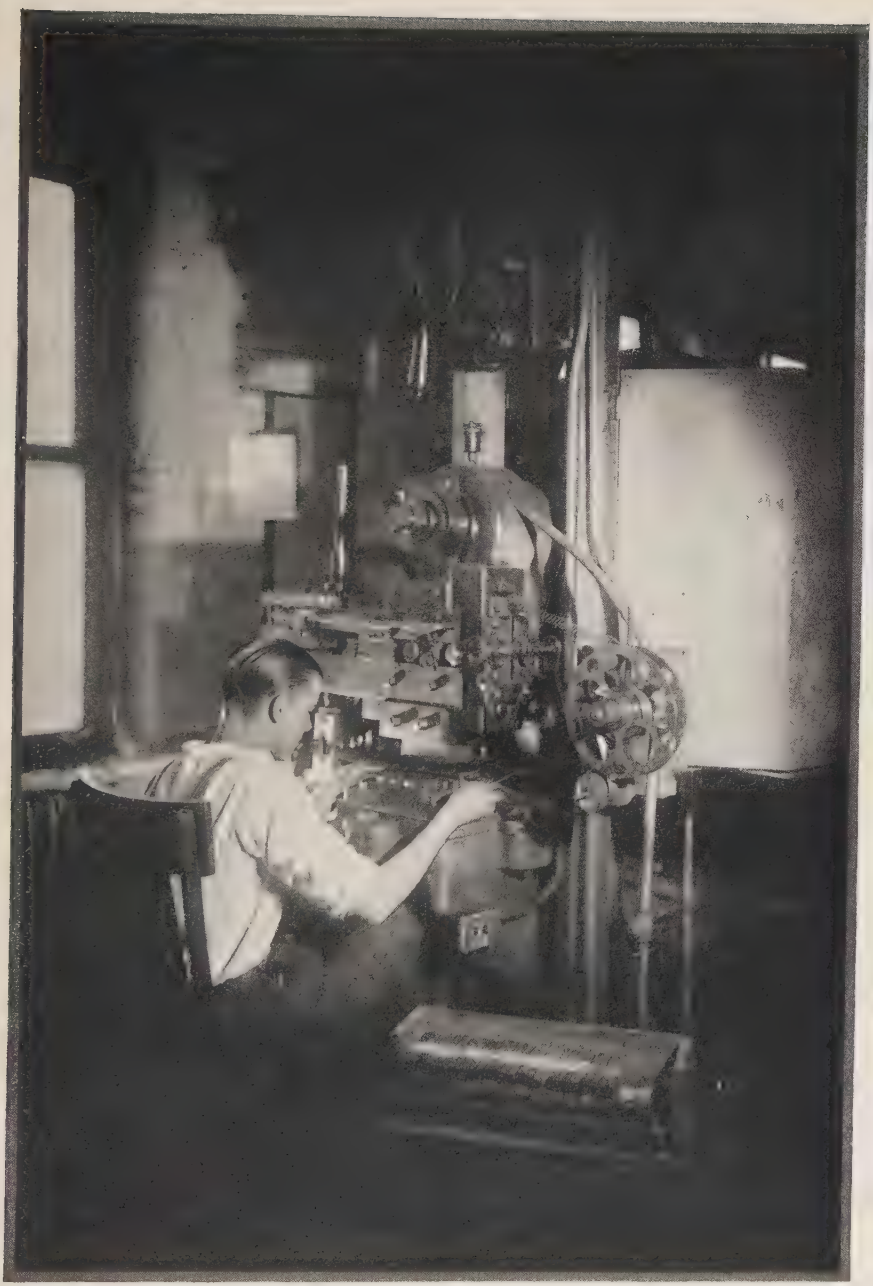
Here, then, in the background is the great institution of insurance which affects the welfare of every community through its sale of protection to millions of firms and individuals.

It is hard to comprehend the vastness of insurance operations. In the fire insurance field alone the stock companies carry a total of about eighty billion dollars of coverage, and to this must be added the very large aggregate of casualty and automobile insurance. Even the newest subject of Laboratories' investigations, that of aeronautic safety, is already represented by a respectable amount of insurance on airplanes and their cargoes.

First and last, therefore, one may visualize the entire burnable property of the United States throughout its

three million square miles of extent and try to realize that all of this unimaginable wealth is, in a sense, tied together by a network of insurance contracts that provide financial security to the holders of more than thirty million separate policies. This financial security is based on payment in case of fire or accident, but its value does not wait upon disaster, for it also forms one of the chief foundations for the credit system upon which business is dependent.

Thus, in a real sense, the interests of all business institutions and all homes—in other words, of the entire population, are dependent on the operations of the insurance companies. But the companies are not mines of wealth, they do not originate the payments which they make—they transmit them, because their ability to pay is due to the premiums collected by them from the policy holders. The rates of these premiums, on which the whole efficiency of insurance depends, are worked out in accordance with carefully prepared schedules representing the many elements of hazard. Now, it is easy to see that if premium rates were not based upon a real understanding of such elements of hazard, they would be nothing more than guesses, and guessing belongs to gambling, not to underwriting. If the guesses were too high, the public would be overcharged for its security; if they were too low, the security would disappear. In either case the public would be the loser and the business of underwriting would be short-lived.



THE BIRTH OF THE FAMOUS LABEL

More than 500,000,000 labels each year are required by the manufacturers of labeled products, and the picture shows the use of a machine for stamping, numbering and cutting off brass labels such as are commonly seen on fire extinguishers, fire doors and other products. The automatic features were designed by Underwriters' Laboratories, which now has under construction an improved machine of its own design that will largely increase the output

EXTINGUISHER OPERATION TEST

Two engineers of the Department of Gases and Oils are asking certain pertinent questions of a 2½-gallon extinguisher. How far will it throw a stream? For how long? At what pressure under various temperatures? What is its reaction to litmus paper? If the range prove to be from 30 to 35 feet; the duration, from 60 to 65 seconds; the maximum pressure, from 85 to 100 pounds per square inch; and the stream prove not acid to litmus, this test is considered satisfactory.

Thus it can be seen that the insurance companies and the millions of policy holders have an identical interest in obtaining *accurate knowledge of the elements of hazard* that must be considered in fixing rates. With contracts representing billions of dollars at stake there is no room for prejudice and no room for superficial judgment. This fact led to the establishment of Underwriters' Laboratories, an institution devoted to the obtaining of accurate knowledge. The companies may be said to be backing the thoroughness, impartiality and technical skill of the Laboratories with billions of dollars of policy contracts, while the policy holders, in turn, are backing the companies with their premiums.

So much for a purely business consideration, but the policy holders have an additional stake in the efficiency of this work in the fact that their lives, as well as their property, are affected.

It is well within the truth to say that thousands of lives are saved each year as a direct result of the busy impersonal labors of the engineers and inspectors on the staff of Underwriters' Laboratories. This explains why the label that epitomizes these labors and makes their findings known to the public has become a subject of nation-wide importance.

CHAPTER SEVEN

Winning the Label

ONE day a boy came into the New York branch of Underwriters' Laboratories, staggering under the weight of a "fire door." He lowered it to the floor, caught his breath, and then told the astonished engineers that he had been sent to get the door labeled and would they please hurry up about it, because the manufacturer had "a customer who was waiting." Of course, the manufacturer was due for a disappointment; the Laboratories' processes cannot go forward at such a dizzy speed. However, the request was only an extreme illustration of a frequent misunderstanding. Many people do not appreciate that safety investigations involve delays that cannot be avoided. It is a serious matter to say that a certain product or process is free from hazardous qualities, or that it will furnish protection if protection be its purpose. Guessing is quick and easy but where human lives are at stake, or where insurance companies are backing the use of processes and products with their policy contracts, guess-work must be eliminated.

The first essential, therefore, is *thoroughness*. Listing

is never awarded to a product so long as there remains a fragment of doubt in the minds of the engineers as to its performance under all the conditions which it may meet in actual use. These conditions may be normal and safe in ninety-nine per cent. of the cases but how about the remaining one per cent? Do they hold possibilities of hazard? If so, the product must be given the test of such conditions; hence, at various points in the following pages, reference will be found to "worst treatment" tests. The Underwriters' label is not easily won, but when won, *it means something.* In saying this, however, a qualification must be emphasized: labels do not necessarily imply the highest attainable qualities; rather they certify the attainment of definite and adequate standards. There is nothing to prevent any manufacturer from producing better goods than are required by the Laboratories' rating—many of them do—but if they fall below the requirements they forfeit their right to the label.

The second essential of all procedure is complete *impartiality.* Any manufacturer whose product complies with the Laboratories' Standards may secure listing, and the keenest rivals meet upon absolutely common ground. To insure this, it is necessary that every step of the testing, inspection and label service for each product be worked out in full detail and rigidly applied to all makes of that product. Consequently, the body of standards and rules has grown to large proportions, yet no one can read them

carefully without realizing that they are both practical and just; they epitomize the technical knowledge and the wide experience of the engineering staff.

This entire activity is focused on a single purpose—*that of determining degrees of hazard in order to point the way to the reduction of hazard.* This is true of all materials and devices that represent inherent hazard, and it is no less true of protective devices whose failure to work at some critical time may result in disaster. Listing means that the degree of hazard, or the degree of prevention of or resistance to hazard has been determined. The label, when awarded, is a certificate of rating in these respects.

How, then, does the Laboratories operate?

Let us suppose that a manufacturer produces a new line bearing upon some form of hazard—fire hose, it may be, or an electrical device, or a safe, or a roofing material, or an automobile lock, or some other of the thousands of different devices and products that come within the range of the Laboratories' operation. Presently, a prospective customer inquires as to "the label". "I carry insurance," he says, "but I can't afford to have my place burn down. *You* say your device is free from hazard, but I can take no chances. If it has been tested and listed by Underwriters' Laboratories I can feel sure."

Thereupon the manufacturer realizes that the Laboratories' rating has a sales value, and he starts out to secure it. From this time he passes through a variety of steps,

some preceding the tests themselves, some related to the tests and still others which are supplementary.

The Laboratories' engineers are practical men who have seen many devices fail under test and know what to look for; therefore, they are able to make expert criticisms which often are of the utmost value to the manufacturer in making the necessary improvements. In hundreds of cases successful devices and products have owed no small amount of their success to the preliminary criticism given by the Laboratories' engineers.

Let us assume, however, that the product in question has passed through these preliminary conferences and now has been submitted for regular test. From this point there begins a series of gruelling experiences—real man-size tests—calculated to "try the soul" of any device. Said the Italian janitor of the New York office as he saw the conclusion of a six-thousand operation test on a batch of switches: "So you do alla you can to busta machine, and if you no can busta you pass it?" Or, as one of the engineers laconically phrased it: "We give it hell." In other words, the device is submitted to tests that will reproduce every conceivable service condition—both probable conditions and those that may be improbable, but still are possible—for the product is destined to go out into a world of careless people and unforeseen emergencies and its qualities must be learned in advance.

In some of the succeeding chapters, glimpses will be

given of these strenuous processes. They are summed up in voluminous reports that bristle with technical terms and prove that there has been nothing superficial, nothing haphazard in arriving at conclusions. Ultimately, it probably will have been shown that the product under discussion is entitled to a classification rating: A, B, C, or, perhaps, D, as the case may be, and each class is so carefully defined that the mere use of a letter carries a definite meaning throughout the trade.

At this point the "submittor" of the device—to use the Laboratories' term—is frequently in a state of excitement and sometimes forgets that the engineers are absolutely impersonal when it comes to their work. One over-anxious submittor, having at last seen his device pass the prescribed tests, after modifications suggested by four engineers had been made, presented each of them with a thousand-dollar watch as a token of his appreciation. The dumfounded engineers turned in the four-thousand-dollar indiscretion to the president of the Laboratories, who promptly sent for the manufacturer. After a stormy hour in the private office, the manufacturer left, carrying his four watches, and never thereafter attempted to repeat his offense.

One important part of the whole process is the "report to Council." In the appendix will be given some idea of the various councils, including recognized authorities of wide experience, who review the findings of the Labora-

INSPECTING THE INSPECTORS OF UNDERWRITERS' LABORATORIES

In this picture the Superintendent of the Label Service Department, from the Chicago office, is seen in a New York automobile lock factory supervising an inspection that is being made by the Chief Inspector of the New York office. The latter, having checked up the parts of steering wheel locks produced at this factory, and made sure that they comply with Laboratories' specifications as to materials, dimensions, heat treatment, fits and clearances, etc., is now making certain that the assembled product is well put together

INSPECTING ARMORED CABLE AT A FACTORY

The Laboratories' inspector is here shown weighing standard length coils of that useful commodity which is widely used in wiring residences. This is one of the important items in the Laboratories' inspection because full weight means that the metallic armor protecting the rubber-covered copper conductors inside it is adequate. The superintendent of the Label Service Department also appears in this picture

TESTING A SPRINKLER LEVER

Many types of sprinklers are sent to Underwriters' Laboratories for investigation. In this case the strength of a lever which is a part of a sprinkler of special design is being tried in a 10,000-pound Olsen testing machine. Ultimately, it will be forced to give way, its deformation being indicated on the dial, and its strength being shown by the sliding weight now being adjusted by the operator's right hand. (See p. 50)

tories' engineers before classifications and labels are finally awarded. These Councils include the Fire, the Electrical, the Casualty, the Automobile and the Burglary Protection Council, and vary in size from eight in the case of the last named to forty-eight in that of Electricity. These authorities must be satisfied as to the accuracy of the conclusions reached, and, if so satisfied, the Laboratories' stage of the investigation may be said to have been passed.

It will be appreciated that certain samples of the product under investigation have proved their worthiness as the result of these tests. However, since these particular samples will not be offered for sale, it now becomes essential to make sure that the actual commercial product will be kept up to sample. Therefore, the work passes into the follow-up service stage; it becomes a factory inspection matter. All over the United States are the plants which produce materials and devices that have been listed, and to these plants there come at various intervals some one or more of the 250 Laboratories' inspectors, operating from a far-flung system of branch offices.

There are three forms of follow-up work, namely, "reëxamination service," "inspection service," and "label service"; certification labels are used only in connection with the last named.

The oldest and simplest is the reëxamination service, in which the Laboratories makes examinations and tests of the appliances one or more times yearly. Products

such as acetylene generators, electric welding machines, fire pumps, etc., come under it.

The inspection service is similar but much more thorough, and its cost is billed monthly to the manufacturers served. Sprinkler equipment and other devices on which it is impracticable to affix labels come under this form. In most ways it is similar to the label service.

For label service, after Council action, an engineer from the interested technical department visits the factory to make sure that it is prepared to produce the device in commercial form; then the Label Service Department provides an inspector in the locality and makes up a special "procedure" handbook to guide the inspector in making his examinations and tests at the factory; in other words, the inspector cannot act arbitrarily, for every action is prescribed in this handbook, a copy of which is furnished to the manufacturer.

The manufacturer may be urgent for labels, but these cannot be given prematurely. When the first lot of goods has been manufactured, a careful examination of it is made, every item being checked against the procedure handbook in conference with the official of the manufacturing company who is designated to come in contact with the inspectors. *Then, and not till then,* the first lot of the labels is delivered.

Thereafter factory inspections are made regularly, preferably when lots are ready for shipment, but sometimes

by surprise. No changes even for improvement may be made in the device, nor may it be manufactured at another factory, without first consulting the Laboratories.

This, in brief, is the story of the winning of the label.

* * *

The preceding chapters have glanced at the growth of human hazard from the few natural dangers encountered by primitive man to the innumerable perils of our complicated modern life. They have shown that man always has been compelled to give thought to protection from these perils, and that, in so doing, he has gradually evolved what may be called standards of safety. In particular it has been noted that the increase of artificial perils since science became a servant of humanity, has led at length to the creation of a scientific institution for the purpose of making a study of these perils and of the protective devices with which man's ingenuity has met them.

Finally, it has been shown how the work of this institution has led to the certification of quality in the case of thousands of products related to fire or some other form of hazard, thus making it possible for individuals and communities to attain a larger degree of security for life and property.

It now remains to show something of the way in which this remarkable activity has both broadened and intensified. It has broadened as more and more forms of hazard have come within the scope of its inquiries; it has intensi-

fied, because the practical nature of its work has led to a constant increase in the volume of demand for its tests. Thus, it has grown into departments, each with its trained specialists who are kept busy in their respective fields.

Work of this character is constantly reacting to the flow of new ideas, issuing from the busy minds of thousands of inventors and taking their forms in the products submitted by thousands of manufacturers. In so doing, the engineers constantly are learning new facts through studying new problems, and from time to time they are able to deduce additional laws. As a by-product to the investigation of specific articles, there is a growing accumulation of practical knowledge which, in turn, flows back into the industries affected and makes possible a constant improvement of their products.

The comparatively new profession of fire-prevention engineering is now being placed upon a solid foundation of knowledge, much of which is the outcome of work in the Laboratories' departments. Even more than this, it is already showing a tendency to sub-divide and intensify, as has been the case in the Laboratories itself. Thus, there are fire-prevention engineers and specialists in the electrical field, in the structural field and in the field of hydraulics, to mention only three. The day is rapidly approaching when specific courses of this nature will be given in many institutes of technology.

The following chapters will show how department after

department has been born to meet some recognized need, has trained its own specialists, has acquired or devised its own apparatus, and has begun to affect the conditions of great industries. In order to obtain this view, it will be necessary to consider in succession the work of the various departments of Underwriters' Laboratories.

CHAPTER EIGHT

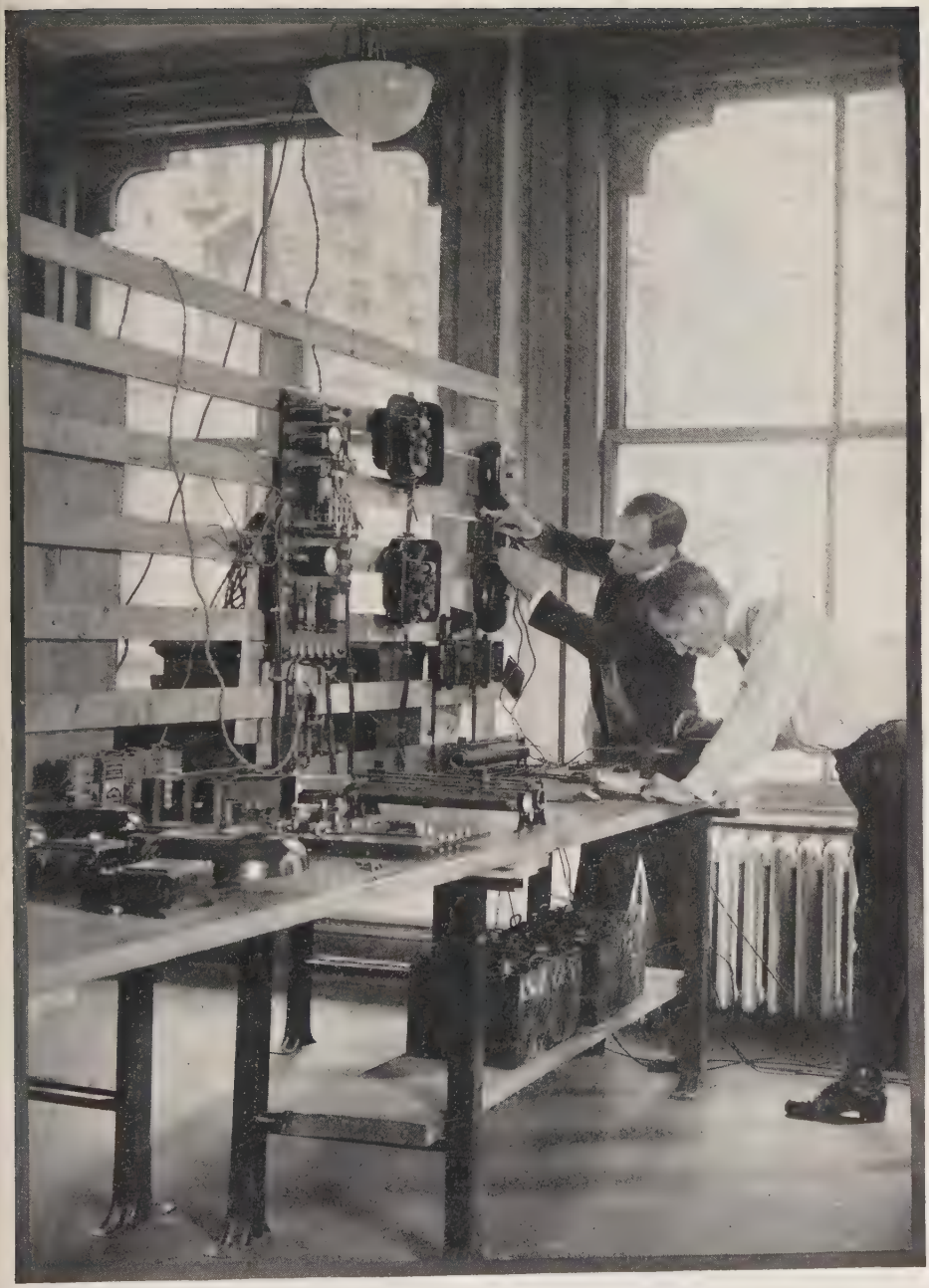
Fighting Fires that Are Not Prevented

1. Detection and Extinguishment

IN SPITE of disheartening loss statistics, there can be no doubt that fire prevention *does prevent* in thousands of cases each day. On the other hand, the conditions of modern life and the vast inertia of human ignorance and carelessness involve hazards so widespread and continuous that the contest sometimes seems to be a losing one. Fire Prevention prevents *fires*, but the time when it can really prevent *Fire*, in its destructive sense, is still far distant. Therefore, civilization must long continue to devote much time and money to fighting the fires that are not prevented. This subject is a large factor in the work of Underwriters' Laboratories.

Fire fighting consists of two elements—*detection* and *extinguishment*, and both of them have led to a multiplicity of devices and appliances, some of them automatic and some associated with human operation. For convenience we may take up *detection* for first consideration.

Fire always announces itself in course of time by means of smoke, smell, sound, the sight of flames or the sensation



TESTING AN AUTOMATIC FIRE ALARM SYSTEM

These two New York Office engineers are trying out an automatic electrical system which not only gives an alarm in the event of fire in the building in which it is installed but announces the floor or room where fire is breaking out, by means of coded taps on the fire gongs. Such systems require painstaking study to determine positiveness of operation. The electrical test here shown is a supplementary one, this system having originally been tested by installing it on the ceiling of a room in which actual fires were lighted while several engineers observed its operation

VIBRATION AND PRESSURE IMPULSE TESTS

In actual use automatic sprinklers and pressure gauges may be subjected to a variety of conditions, the effects of which it is important to learn in advance. In the picture, a hydraulic engineer is making tests by means of a motor-operated vibration and pressure impulse machine

of heat, but this may be at a time too late to prevent destruction. The art of fire detection is that it be discovered in its earliest stage when loss may still be prevented. To this end, there has been a wide development of fire-detection systems and here again the classification is two-fold; viz.: those based on automatic signaling by the fire itself, through its effect on some mechanism; and those which are accessory to the work of a watchman or patrol, such as time-recording clocks, pull-boxes, etc. Both classes may be good or bad in design, well or poorly made, in order or out of order at the time of need, as with most things mechanical, but both of them are charged with so serious a responsibility that possible failure must be guarded against in advance of the emergencies when such failure would be disastrous. It is the work of the Laboratories to determine, and thus to aid in correcting, all liability to failure.

2. Alarm Appliances

In fighting fire, it first must be discovered. Therefore, automatic alarms in great variety have been devised on the principle of making fire tell on itself. This it never hesitates to do when the right conditions are provided.

Fire can thus be made a much better fire watchman than are the mere humans employed for that purpose. Indeed, human watchmen so frequently are inefficient that there has been much discussion in insurance circles

of what is familiarly known as "the watchman evil." For example, a watchman smelled smoke one Saturday night, but failed to find where it came from and told the Sunday watchman that it was due to a banked boiler. The smoldering fire was permitted to burn all Saturday night and during Sunday and Sunday night as well. On Monday morning the attention of a passerby was attracted by smoke pouring from the windows. This passerby ignored the assurances of the watchman and called the fire department, which succeeded in extinguishing a fire that was rapidly becoming serious.

In another case a night watchman was disturbed in his slumbers by the persistent ringing of a bell attached to the automatic fire-alarm system. There was a fire, and it was trying to tell on itself, but the watchman was not able to draw the inference; on the contrary, he climbed on a chair and stopped the ringing by forcing the blade of his penknife alongside the clapper of the bell. Then he went quietly back to sleep. Two or three hours later he was awakened by the dense smoke with which the room was filled and went down to the street for fresh air. There, wandering about, he found another watchman supposed to be on duty in an adjoining building, and this man offered to go back with him and seek an explanation of the strange phenomenon. Putting his hands on the wall, he found that the bricks were hot. "Perhaps," said he, "there is a fire!" On this possibility they turned in an

alarm, but some $50,000 worth of damage was done before the firemen could subdue the flames.

These are merely a few cases out of many indicating the fallibility of depending on human vigilance and the desirability that fire be made to summon outside assistance. For such reasons, inventive ingenuity is always active in this field, and fire-alarm systems are under constant investigation by Underwriters' Laboratories. One type in wide use is operated by a valve attached to the automatic sprinkler system. As soon as a sprinkler head is opened by the fire the motion of the water causes an alarm to sound.

On the other hand, much of the work on alarm systems and devices is done by the Electrical Department, and the electrical circuits on some systems are remarkably complicated as, for example, in the case of those known as "non-interfering" by means of which several alarms may be sent in simultaneously from different points without interference at the central station.

3. Standpipes and Hose Stations

Iron standpipes and hose connections are to be found in the hallways of most tall buildings. Their necessity is too obvious for comment, for imagine the awkwardness of having to carry hose up many flights of steps in fighting fires on upper floors. Whether these systems be of the "wet" type, in which water pressure is constantly main-

tained, or of the "dry" type, into which water must be turned before fire streams are available, it is evident that the pipe itself must be good, that the hose stations attached to it on the various floors must be convenient and easy to operate and that these hose stations must be made as nearly "fool proof" as possible.

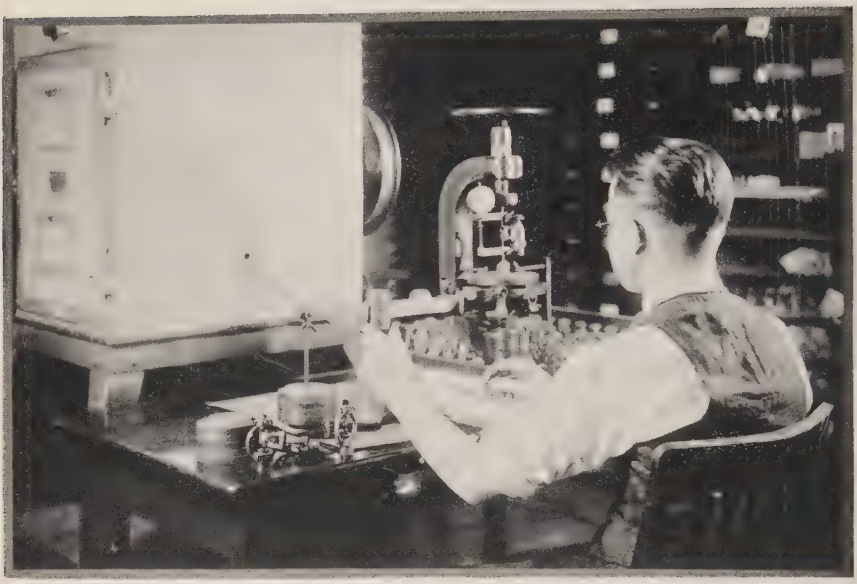
An ordinary investigator might think it sufficient merely to look things over and, perhaps, to give the system a trial operation in place. Not so with the Laboratories' engineers. They make micro-photographs of the iron or steel to learn of its structure; they test its strength and elasticity by means of powerful tension and compression machines; they carefully examine the inner surface because roughness means friction, and friction under some circumstances may cause the stream to fall short of the flames it is desired to extinguish. So, too, with the hose stations. Their various requirements must be investigated with great care in view of the fact that they are likely to be used by inexperienced people laboring under excitement—a point never to be overlooked in making tests.

4. Sprinkler Equipment

"The manufacturer who today builds without provision for automatic sprinkler protection almost wilfully endangers not only his plant but the life of his employés," so says the Secretary of the National Fire Protection Association. Automatic sprinkler equipment is undoubtedly the

SOME "HORRIBLE EXAMPLES"

However good a sprinkler head may originally have been, it cannot operate if seriously corroded or if heavily loaded with dust, lint or other foreign material. This cabinet contains heads taken from actual service. One was gummed by flying varnish, another was clogged by a wasp's nest and still others were seriously corroded or otherwise impeded. They form an object lesson in the importance of inspection and maintenance



DETERMINING THE STRESS ON A SPRINKLER LINK

The operator has his eye fixed on a very sensitive Ames dial, while his left hand slowly increases the weight on the beam of the weighing machine, and a pencil in his right hand records the exact point of release. Note the number of sprinkler heads visible in this photograph. The Laboratories uses 150 of each type in order to determine uniformity of operation and other characteristics

OPERATING TESTS ON AUTOMATIC SPRINKLERS

Sprinklers must be responsive to heat, but all the conditions of their response must be known in advance of the emergency which will call it into play. The illustration shows a gas-heated, water-jacketed, cylindrical oven, where the temperature is raised according to a predetermined standard temperature-rise curve. The temperature at which the link fuses and the behavior of the operating mechanism are carefully noted

greatest single device for reducing fire loss, and in thousands of buildings may be seen the familiar little sprinkler heads, quietly awaiting the time when heat from a fire may melt a small piece of fusible metal and allow water to gush forth in a drenching shower. It is estimated that 20,000,000 people are now under the daily protection of sprinklers and that during the past twenty-seven years this form of protection has successfully controlled 95.7 per cent. of 26,888 recorded fires.

So highly is the sprinkler esteemed by insurance companies that they make large reductions in premium rates where it is employed, provided that it be of approved type. This qualification is important, for there are "sprinklers and sprinklers." Inventors have been especially busy in this field and hundreds of devices have been submitted to Underwriters' Laboratories for test; and tests they have received, tests so searching in regard to the many qualities required that the Laboratories' standard for sprinklers alone is a book of about thirty thousand words. These tests occur almost continuously and the visitor to the Laboratories is apt to find them in some stage of process. He may see the hydrostatic-pressure test, during which a steadily increasing pressure searches out the weak points in the sprinkler, or the "water-hammer" test, whereby four thousand vigorous hydraulic blows are delivered, followed by investigation for leakage; or, he may see some one of the "installation," "accuracy of release" or

"excessive stress" tests. He may see sprinklers tested after having been subjected to chlorine or nitric acid fumes or coated with calcimine, as might easily be the case in actual use. He may see them struck with hammers or thrown on cement floors, under the specifications for "rough usage" tests. He may see them tested for distribution, in order to learn the exact area of floor or ceiling that they will cover with spray, or mechanically tested for strength, or he may see uniformity tests made upon 150 or more samples, and other efforts made to determine all of the points of possible weakness or inefficiency, which might spell life or death in a fire emergency. In view of this, it will hardly surprise him to learn that out of the hundreds of types submitted, only some fifteen heads have the final listing.

The qualities of the sprinklers, when once determined and rated, are made the subject of factory inspections, as with most other lines, but the most remarkable feature of the Laboratories' work on sprinklers consists in taking heads for test from buildings throughout the country, where they have been in service for months or years, as the case may be. This service involves from four to five thousand samples each year and is performed without cost to the owners of the buildings. Reports are sent to the insured, to the interested inspection department and to the sprinkler companies concerned, however, it must be added that the name and address of the assured are deleted from the copies

sent to the sprinkler companies. As a result of such tests the Laboratories makes definite recommendations to the owners of the buildings as to whether the heads should be retained or taken out.

5. *Fire Hose*

In 1911, President Merrill, in speaking before the Fire Underwriters of the Pacific, said:

> We find [fire hose] manufacturers making a monstrous mystery of their wares, analysts proving them rotten or unfit for use and gossips busy with details of scandal about the reasons why inferior hose is delivered, when *superior* is supposed to be paid for from the public treasuries.

There is perhaps no single item of municipal supplies whose purchase has been associated with more irregularities than this vital factor in public safety. It is a matter of common gossip that a well-known politician in one of our great cities was conceded the fire-hose graft as his own personal reward for political services, and similar conditions were to be met in many other cities. As a result, it is not astonishing that, times without number, length after length of defective fire hose purchased with the good money of the taxpayers burst as soon as water had been turned into it. Under such circumstances, fires that might readily have been controlled have grown to large proportions and a ghastly list of human victims is chargeable to defective hose.

For example, on January 10, 1908, fire broke out in the Parker Building on Fourth Avenue, New York City, and the firemen were hampered by the fact that forty-two different lengths of fire hose burst under the water pressure. This undoubtedly was one of the reasons why the fire caused heavy damage before it was brought under control; still worse, it was one of the reasons why three firemen lost their lives and fourteen others received serious injuries.

Sometimes similar conditions prevail in the equipment of private plants. A characteristic instance of this kind occurred several years ago in a Pennsylvania cement-manufacturing plant, where a fire broke out in a bunker, presumably from a locomotive spark. The fire was quickly discovered and the plant's fire-squad coupled up the plant's expensive new hose and turned on the water, whereupon the hose burst in five or six places and the fire merely gained headway. The disgusted squad hurried to uncouple the hose and threw in another length, which immediately burst like its predecessor. Ultimately, the loss amounted to $7,000 which was almost entirely due to the failure of the hose.

In this case the plant management had "specified and paid for" hose inspected by Underwriters' Laboratories, but had neglected to "look for the label," and the dishonest dealer had substituted a worthless product.

Fortunately, such conditions are becoming less frequent today, a fact that is largely due to the widespread in-

TESTS ON AUTOMATIC SPRINKLERS

It is said that automatic sprinklers are guarding the lives of 20,000,000 people, therefore, the tests as to their efficiency are of supreme importance. In the picture, the engineer at the left is making a leakage test, while the one at the right has plunged another sprinkler into a hot liquid maintained at a certain temperature in order to observe, by means of a stop watch, how many seconds will elapse before it operates

FACTORY INSPECTION OF COTTON RUBBER-LINED FIRE HOSE

In this work, every single 50-ft. length of hose produced by the manufacturer for labeling is subjected to hydraulic pressure under the eye of the Laboratories' inspector—300 lbs. per sq. in. for single-jacketed and 400 lbs. for double- or multiple-jacketed. The Laboratories' inspector is shown observing the performance of the length nearest to him on the test table. He watches for elongation, twist, warping, rise from level of table, security of couplings, etc.

sistence on "Underwriters' fire hose," or labeled hose complying with the standards laid down by Underwriters' Laboratories.

The "monstrous mystery" referred to by Mr. Merrill has been dispelled by the clearness of the Laboratories' requirements for municipal fire hose. For instance, the first requirement is that the fifty-foot sections be stenciled in indelible letters and figures at least one inch high, with the trade name, the month and year of manufacture, and the words "tested to 400 pounds"; the Laboratories' label must also be firmly attached near an end. It serves more than one purpose, as a crooked jobber found out to his deserved sorrow when he tried to pass off as new a lot of old hose on which the stenciled dates had been altered. The prospective customer became suspicious and notified the Laboratories' local office, where he was informed that the labels had been affixed to a War Department supply some years earlier.

Fire hose is such an important product that it comes under the "100 per cent. inspection" system of the Laboratories; that is to say, *every* section of hose sold with the Laboratories' label attached to it has been inspected and tested individually at the factories by the Laboratories' inspectors. Each length of hose, before being labeled, must withstand a pressure of 400 pounds per square inch, without leaking, sweating, breaking cover threads, shortening, rising from the level of the test table or warping

more than twenty inches, nor may it twist excessively under the strain, and, if it does twist, it must do so in a direction to tighten the coupling. One full length out of every ten must be tested *while kinked* and it is required that its cover threads shall resist a pressure up to 300 pounds per square inch. From every lot of sixty sections, one is selected and a three-foot sample is subjected to hydraulic pressure that is steadily increased until the hose is forced to burst, a point which may not occur below 600 pounds to the square inch. Finally, the manufacturer must guarantee to the municipality that the hose is made according to the best principles of hose construction, that it is free from defects of material and workmanship and that if, at any time within three years, the rubber parts of any section burst or show cracks or harden, because of defects, such hose shall be replaced with new hose at a cost equal to such per cent. of the original cost as the time elapsed is of three years.

Preceding such factory inspection, however, and from time to time thereafter, thoroughgoing tests of test samples are made at the Laboratories itself, and these are in the hands of the Chemistry Department, since they concern themselves chiefly with the character of the rubber and cotton employed. This is because the rapid deterioration to which some hose is subject is largely due to inferior quality in its materials.

The tests concern themselves with minute but highly essential details, as laid down in the rigid specifications. For example, it is provided that the rubber lining of a two-and-one-half inch double-jacketed cotton rubber-lined hose must consist of not less than three calendered sheets with a thickness between .058 and .072 in. and "practically free from corrugations". Similar definiteness applies to all other details, including even the fact that the hose coupling must contain not less than "82 per cent. of copper". Thus no room is left for a shred of "mystery" in the manufacture of fire hose.

These are the reasons why the average fireman is now able to enter a burning building with confidence that the hose upon which his life may depend will not fail him in service.

6. *Hydraulic Tests*

It is fortunate for humanity that water, the most reliable of all fire extinguishers, should be so plentiful in a world of hazard. The water supply is the most important part of the fire-fighting system of every community, and its pipes, valves and fittings come in for extensive tests at Underwriters' Laboratories. This is why the institution contains an elaborate hydraulic laboratory.

Back of the work of firemen, sprinklers and standpipes there must be the means by which they are supplied with water; these involve pumps, hydrants, valves and, in

some cases, complicated supervisory systems, all of which keep the Laboratories' hydraulic engineers busy throughout the year. Offhand, one would think that any valve could be examined and tested in a few hours, but alarm valves require each about four weeks of steady work by the engineers, and dry-pipe valves likewise present many problems for consideration before the Laboratories can render an opinion. The ideal alarm valve must cause a gong to ring or a signal to flash, or both, but it must ignore false alarms. This problem, by the way, has never fully been solved, though in some cases Laboratories' engineers have, at manufacturers' requests, devoted months to development work on this device. As to dry-pipe valves, they are used in premises that may become cold enough for the water to freeze in the fire-fighting system. This invention is quite as remarkable in its way as is the alarm valve. It must hold back the water until a sprinkler opens, when it must immediately open in turn, so that as few precious seconds as possible will be lost while the water rushes to the point of fire. Only five of these valves have received favorable opinion and have been listed by the Laboratories.

The importance of such listing is shown by such instances as the following:

"When fire broke out in a sash and door factory, the two 12-in. alarm bells in the outside of the building and the 6-in. bell in the stableman's dwelling did not operate.

A VALVE WHICH GIVES AN ALARM

Fire not only should cause the flow of water from the sprinkler, but it also should send in its own alarm. An alarm for this purpose is here shown under test in the interesting hydraulic laboratory, and the minimum flow of water required to make it operate is being determined. The device under test is the small rectangular box in the right-hand margin of the picture

TESTING THE STRENGTH OF A GATE VALVE STEM

Here is another view in the hydraulic laboratory. The gate valve is seen on the floor, with one flange securely bolted to the steel platform, while pressure is being exerted on its bronze stem by means of a lever, the extent of the strain meanwhile being measured by a spring balance

No less than forty-seven sprinklers were found to have opened, so that the dry-pipe valve must have been too slow in operating."

Ask any hydraulic engineer specializing in pumps whether he has ever heard of Underwriters' Laboratories and he will probably answer: "Why, the approved fire pumps are all commonly known as Underwriters' pumps." That tells the story. As a matter of fact, some manufacturers use that characterization in their catalogs and put big brass plates on their labeled pumps, bearing the word UNDERWRITERS in large letters. There are hundreds of water pumps on the market, but only a few "Underwriters' pumps," the principal points of difference being that the latter embody almost every known improvement making for durability, reliability and *instant operation.* It is regrettable that many owners of tall buildings do not realize the necessity for providing fire pumps in addition to the supply tanks, and that some owners do not even have the latter.

7. *Chemical Extinguishers*

Ten cents' worth of baking soda in a five-cent tube—such was the so-called fire extinguisher sold for three dollars to the owners of the Iroquois Theater in Chicago in 1904. A mechanic testified that in its incipiency the terrible fire, which cost over six hundred lives, could have been put out with a small stream of water, but the "extinguish-

er" was used as per directions until it was too late even for hose streams.

Labeled fire extinguishers effectively put out a fire in a New York subway car in July, 1922, at a point far below street level. Passengers painfully climbed seventy-foot ladders, ambulances and fire engines rushed to a scene of confusion, and at first there were sensational reports that fumes arising from the use of the extinguishers had poisoned the lungs of the passengers. Later, experts from the Transit Commission and the U. S. Bureau of Mines reported that the "smoke and fumes were principally from burning insulation, paint and other organic matter" and that there was no evidence that poisonous gas was generated through the application of the extinguishers used.

If it were not for the establishment of rigid standards certified through labels, frauds would doubtless be perpetrated upon an ignorant and unthinking public, which buys make-believe extinguishers and imagines defects in good ones.

The importance of this whole subject of what are commonly called "first-aid" fire extinguishers can hardly be over-estimated since they are used in fighting scores, possibly hundreds, of small fires every day in the year. The number of cases in which efficient extinguishers, promptly applied, have prevented incipient blazes from becoming serious, is beyond computation; the sense

of security that most people feel in their presence is undoubtedly due to the high average of their performance. This, in turn, has been influenced by the fact that in this class of product, more perhaps than any other, the general public has learned to "look for the label" of Underwriters' Laboratories. More than six million of these small hand-operated extinguishers have so far been labeled and the present rate of labeling (1923) is about three hundred thousand a year.

Thus, in factories, stores, public buildings and hundreds of thousands of homes the eye has become accustomed to the familiar two-and-a-half-gallon copper extinguisher or the smaller one-quart device, both of which hang on the walls in silent readiness for immediate action. To these must be added the well-known fire-pail which renders important service in every community.

The words "immediate action" explain most of the tests that are made on first-aid fire extinguishers by the Department of Gases and Oils which has them in charge. Such extinguishers do not protect by their presence but by their use. This use is generally in the hands of amateurs, in a state of excitement, and is made during the precious "first five minutes." There is no time to tinker, adjust or study; the whole device must be swift and efficient when the emergency occurs and it is the business of the engineers to find out whether it is likely to be.

For example, some fluids are subject to freezing unless

kept in sufficiently warm places and, naturally, a device cannot be used when frozen. In spite of warnings and directions very many extinguishers are allowed to freeze by careless owners and the question as to the degree of permanent impairment resulting from such freezing is important to determine. The freezing may weaken the device in a way that will not become apparent until there is an attempt to use it in a sudden fire emergency, when it may give way with serious results.

On the other hand, if the extinguisher be torn apart by the freezing, the solutions when melted will run out and advertise the fact, thus giving the owner ample warning that the ruined device should be replaced. Even in such a case the general temptation is to have the extinguisher repaired, and where this is done, without proper knowledge of the problems involved, the general results give a false sense of security. A sample of such an experience was recently brought to the attention of the Laboratories in a report to the effect that a labeled extinguisher had exploded, as a result of which the device was secured and carefully examined. This examination disclosed the fact that the vertical seam had evidently been torn apart by freezing, and the repair had been made by springing the edges together and simply soldering them without any attempt to secure further strength than that given by the solder. When this device was used, the soldered joint, of course, failed and threw the extinguisher parts

HOW STRONG IS THE EXTINGUISHER SHELL?

In the operation of a soda acid chemical extinguisher, a considerable gas pressure is developed within the shell in order to force out the stream. It is important to make sure that the shell will not burst, and it therefore is subjected to a pressure of 385 pounds per square inch in the test here shown. Then its distortion is carefully measured, after which the pressure is gradually increased until the shell is forced to break, the exact bursting pressure being recorded

TESTING A 33-GALLON CHEMICAL EXTINGUISHER

This important type of "first aid" apparatus is frequently equal to the task of subduing a fire. In the picture, it is under test as to the pressure developed in the tank and the nature and carrying power of its stream. Students from the Armour Institute of Technology are seen as interested spectators

with considerable violence, but fortunately without injury to the operator.

There have been many efforts to find some practicable way to lower the freezing point of extinguisher contents, but many tests have failed to show a depressant that is free from objection. For example, a solution of common table salt, while it will lower the freezing point, is sure to produce corrosion and resultant weakness.

As an example of this, a number of years ago an extinguisher exploded and an examination of the fragments indicated that the metal at the water level had been eaten away to almost paper thinness, except, of course, at the double thickness of the longitudinal joint. When this extinguisher was operated the pressure generated was sufficient to tear away the dome of the extinguisher.

This, of course, is but one of the many points concerning the two-and-a-half-gallon extinguisher which call for careful investigation in painstaking tests.

The one-quart tetrachloride type works on a different principle and calls for tests of a different character. Its fluid has the important virtue of being a non-conductor of electricity, hence is often used in this connection.

In their development the engineers of the Gases and Oils Department made use of many different types of fires to demonstrate the limitations and value of this type of device. Electrical fires, consisting of arcs produced under high voltages and heavy current, were attacked

with devices of this kind with results which indicated the value of the non-conductive liquid and the smothering effect of the vapors formed. Tests were made at the stations of some of the larger electric lighting concerns in Chicago and New York, and the effectiveness of this type of extinguisher for electrical fires was thoroughly demonstrated. Fires in inflammable liquids also were attacked in order to indicate what a single device of this type would do; such tests included liquids in tubs and liquids spread on the floor and absorbed by various kinds of fabrics such as burlap, cotton batting and cotton waste. In all of these tests the engineers of Underwriters' Laboratories were constantly exposed to the products of combustion and the fumes given off from the extinguisher, but, although the engineers were many times forced to flee from the test room by the smoke and fumes, at no time was any engineer injured or materially incapacitated.

"The work of the Laboratories," to quote one of the staff, "may be considered as similar to that of a clearing house for many varieties of fire extinguishers, which if described would provide an interesting volume. It might be expected that invention has practically exhausted itself along these lines, but such is certainly not the case. Hardly a day passes by that some thought or idea in methods in connection with extinguishing fires is not presented. New chemicals are presented, and more

frequently well-known chemicals in new combinations are submitted for consideration."

A great deal of research and improvement work has been done by Underwriters' Laboratories on all kinds of chemical extinguishers from the one-quart size up to the automobile chemical fire-engine.

The preceding pages indicate but a few of the main features of Underwriters' Laboratories' work with regard to fire-fighting equipment. In most American cities fire-fighting is in the hands of professional fire departments which employ large apparatus that is tested in the locality of its use by engineers of the National Board of Fire Underwriters. Fire hose and alarm systems are the main items affecting the work of fire departments that receive inspection at the Laboratories, although of course all such matters as sprinklers, valves, standpipes and even portable chemical extinguishers are part of the fire-fighter's problems.

CHAPTER NINE

Building to Last, Not to Burn

1. Studying Burnable Conditions

A CURRENT joke among New Yorkers before 1897 was that the only fire-proof building in the city stood on the corner of Fifth Avenue and Forty-Second Street. If curiosity prompted one to investigate he would find the "fire-proof" building to consist of the Reservoir—a massive stone wall enclosing and impounding 24,000,000 gallons of water.

The reservoir was demolished at last to make way for the Public Library, and the question as to whether New York now has even one *completely* fire-proof building is open to debate. Certainly many buildings are more or less fire resistant, but a much greater number seem to burn so readily as to suggest that the city's streets are lined with thousands of prepared bonfires, awaiting only the touch of flames.

This also is true in all other American cities and towns, and with the usual run of country buildings, but it is conspicuously untrue with regard to many foreign countries. Indeed the contrast between fire losses in America and Europe is so striking as to indicate the existence of very fundamental reasons which, on investigation, prove

A "CLOSE-UP" OF A CONFLAGRATION

That is practically what is pictured here, in so far as it applies to the fire-resistance of roofing. If your house were covered with these shingles, how well would it be protected? The roofing itself answers this question by its behavior under many tests, one of which is here shown. Gas burner flames are being driven against the sample by the wind from a powerful blower, while observers note how long it takes to ignite, whether glowing fragments are detached, etc.

HOW ACCURATE ARE THE PRESSURE GAUGES?

Merely to look at this small piece of apparatus one would hardly imagine that it is capable of exerting pressures up to 25,000 pounds per square inch, in checking the accuracy of a gauge (See p. 253)

EXTRACTION APPARATUS FOR RUBBER AND ROOFING

"Rubber" is not necessarily rubber. There are countless adulterants which affect its qualities. This is an important matter in fire hose, insulated wire and other products. Similar conditions apply to the saturating and coating compounds used in roofing. The photograph shows a chemist placing a sample of rubber in a flask preparatory to extraction with acetone. For obvious reasons this room is ventilated by means of a powerful exhaust fan and the visitor hardly notices the variety of odors

to be three-fold, viz.: our traditional American carelessness as compared with the thrift and precaution of an older civilization, our larger employment of hazardous devices and processes, and, chiefly, the highly combustible character of our buildings.

It is but a few generations since our forefathers found themselves on a new continent, abounding in forests which offered an apparently endless supply of inexpensive building material. It was inevitable that frame construction should come into general use, and it was a natural consequence that fires should become so frequent that Americans looked on them as more or less matters of course—"acts of God"—although better-built Europe did not so regard them. Characteristic American optimism was willing to "take a chance" in the matter of fire hazard but the results finally grew sobering, even to optimism. Then it was realized that buildings must be built to last, not to burn, and architects and engineers gave a very tardy recognition to the importance of the subject of fire prevention.

Before long they found themselves handicapped by lack of information. They knew that a single brick or block of stone would not burn, and assumed that a building of brick or stone would not burn, but were distressed to find that such buildings often proved to be fire-traps. Apparently it would be necessary to master other factors before fire-proof or even fire-resistive construction could be

thought of. This was a matter of life and death to thousands and of vast property values. How, then, might this knowledge be obtained?

The study of conflagrations revealed much, but the results might be misleading because of the uncertain conditions of the fire. After each big fire, manufacturers were stimulated to produce new forms of roofing, partitions and other structural material which were confidently labeled "fire-proof" until another conflagration might show the fallacy of the claim.

Finally it came to be realized that there was no possibility of checking the nation's mounting fire-waste unless severe fire conditions could be produced *under control and under expert observation* for the purpose of testing and determining the qualities of various building materials before they were actually employed.

Underwriters' Laboratories began this work in 1903 and it soon grew into one of the principal activities of the institution. Today, the tests of building materials have included a great variety of products representing thousands of different manufacturers and the Laboratories' influence is felt in the whole field of building design and construction. Probably generations must elapse before American towns can be rebuilt along safer lines, but the steps already taken in that direction are appreciable and many of these steps are directly traceable to tests conducted on East Ohio Street.

It has been a rather fanciful dream of the Laboratories that buildings might some day be constructed entirely of labeled materials and completely equipped with labeled installations so that the buildings as a whole would be entitled to bear the label of the Laboratories. That this is not wholly imaginative is shown by the fact that the main testing station on East Ohio Street approximates such conditions of safety. From every standpoint it has been safeguarded to a degree that makes fire hazard almost unthinkable.

The subject of building material tests is well worthy of a closer view and a glance will now be given at some of its sub-divisions.

2. Roof Coverings

Most conflagrations are associated with wooden shingle roofs. The original fires may be due to many causes; to Mrs. O'Leary's cow (if this famous animal ever really existed), to shoe-heel lacquer in a Salem workshop, even to the overflow of a river causing the sudden slacking of lime in a Georgia basement. In most cases, however, the fire is trifling until it begins to travel, and its favorite method of travel is from roof to roof.

A general conflagration is a terrifying thing. It calls to mind great clouds of acrid smoke, a roaring advance of wind-driven flames, and a rain of flying sparks and brands upon the roofs in its pathway, so that these latter

sometimes begin to burn blocks ahead of the main fire. With it all, there is the panic-stricken activity of the threatened inhabitants rushing to escape or to save what they may of their possessions. A conflagration is the most dramatic event in American city life; it is of all-too-frequent occurrence, yet it is almost unknown in European cities with their solid buildings and their slate, tiled or metal roofs upon which sparks or brands merely burn themselves out.

But America is a land of wooden shingle roofs—millions of them; they are a tradition of our history because they are cheap, easily applied and easily repaired.

However, the accumulated lessons of fires became so unmistakable that, rather less than twenty years ago, there developed a great demand for durable, inexpensive, fire-resistant roofings to replace the wooden shingle.

Demand is usually followed by supply, and soon manufacturers produced various forms of roofing that were marketed as "fire-proof". In actual fires, these did not always substantiate this claim and the underwriters, by whom roofing is regarded as an important element in influencing the spread of fire, realized the need for exact knowledge on such a vital matter. As soon as the question of roofing began to affect insurance rates, both users and manufacturers saw the necessity for an authoritative judgment and Underwriters' Laboratories, in 1906, began to make roofing material a subject of test and classification.

At first the tests were rather crude, the principal one being the dropping of red-hot cast-iron discs on the roofing samples. Nevertheless, so carefully were the observations made that there has been no instance in which labeled roofing, in use, has failed to fulfill the requirements of its classification.

Ultimately the investigation developed into its present form in which a careful and *standardized* study is made into various questions of design, construction, practicability, durability and other items as well as into the direct question of ability to resist heat and flames.

The items in the resulting report represent a greal deal of work. For instance, "Physical Tests" really includes also some thorough chemical tests. To the untrained eye, there is little difference between a piece of rag-felt roofing saturated with a coal-tar pitch and a piece of asbestos-felt roofing impregnated with asphalt, but they have different properties. Even the word "asphalt" is not sufficiently definite because there are asphalt deposits in Trinidad, Utah and elsewhere, from which many varieties are extracted, each of which has certain properties, and the various manufacturers have formulas of their own for mixing their saturants, impregnating compounds and coatings. The Laboratories must know just what the test samples consist of, so that year after year it may check up on the manufacturer.

The fire tests are three-fold: Frequently roofing en-

counters severe heat without being touched by fire brands, and sometimes bursts into flames from the heat alone. This is tried out in the first test, in which a drum-shaped gas-fired oven is heated until the bottom plate glows red at 1100° F. Then the roofing, which is laid on a wooden deck as in use, is moved to within ten inches of this plate and is subjected to the heat until flames appear on the under side of the deck. Everything is standardized, as in all other tests, in order that each make shall be tried under the same conditions.

The next test involves burning brand exposure. A standard brand is ignited, placed on the roofing sample and allowed to burn itself out. Some roofings fail under this test as is shown by the burning of the roof boards; with others, the boards are uninjured. Every detail is recorded carefully and photographs are taken.

Then comes a more severe exposure, that of wind-driven flame. This is really spectacular, for a roaring mass of flame impelled by a twelve-mile wind from a blower, leaps from a thirty-six-inch burner and attacks the surface of the roofing. This test continues until the roof deck boards are ignited. The time is noted as well as the rate of the spread of flame over the roof covering during the test. The blower, by the way, is used in connection with the other tests, and the twelve-mile rate was determined upon after studying the weather reports of many years.

When roofing has undergone these and still other ordeals and has been recorded and photographed, there is no longer room for guesswork as to the claims of its manufacturer; its fire-resistant qualities are known and the classification label awarded to it by the Laboratories shows exactly what can be expected of it by the public.

3. Windows

On the night of March 15, 1922, the upper eight floors of the Burlington Building in Chicago were swept clean of their contents in a great fire that involved fourteen buildings. This fire caused much discussion because of the fact that the Burlington Building had been considered a fine example of modern fire-resistive construction and many people jumped to the conclusion that the theories of fire-prevention engineers had been disproved.

Investigation showed, however, that these theories had been proved, not disproved. The building was an excellent example of safety construction with one fatal exception. There was nothing astonishing in the performance of any of the materials which made up that building; steel, brick, terra-cotta, hollow tile, plaster block, bronze, marble, wired glass, *window glass and wood.*

The whole trouble was that these last-mentioned materials, window glass and wood, were used where they should not have been used. On each floor of the Burlington Building facing Clinton Street there were nineteen

ordinary glass windows in wooden frames. From the ninth to the sixteenth floor these all were damaged very early by the heat from across the street. About thirty minutes after flames broke through the roof of the building where the fire originated—two hundred feet from the Clinton Street side of the Burlington Building, J. C. McDonnell, Chief of the Bureau of Fire Prevention, "noticed that the wooden window frames of the Burlington Building were igniting" and on Clinton Street he "found window glass falling like a hail storm."

Almost immediately after these windows failed, the combustible contents of every upper floor were burning. In a few minutes the wooden flooring, doors, frames, etc., also were burning.

In expert discussions of this fire (or rather of these simultaneous fires on the upper floors) the opinion has been expressed that light combustible objects were ignited by the radiant heat from across the street even before the window glass cracked. This fire was merely a striking example of the facts that fire frequently makes its entrance to a building through the windows and that window protection must never be neglected where there is the chance of exposure from outside.

In 1903 Underwriters' Laboratories began to test "fire-windows." Not a single so-called "fire-window" passed. "They failed miserably." Underwriters' Laboratories' tests were considered a joke. The majority of manufac-

TESTING A METAL WINDOW FRAME

The frame set with panes of wired glass is subjected for one hour to the intense heat of roaring gas flames. Almost immediately, the glass cracks in many directions. Somewhat later, the iron framework begins to bend inward slightly toward the flames. In the picture, the one-hour exposure is nearly completed and an observer at the right is taking the measurements of the distortion of the window frame. A little above his measuring device there is a suspended pole on which strips of cloth are hung at various distances in order to show the effect of the radiated heat on combustible material. One of these strips has just burned and fallen to the floor

FIRE-STREAM TEST ON METAL WINDOW FRAME

The movable wall containing the metal window frame has just been rolled from the furnace and the glowing window is being deluged with a fire stream on the side of it which has been exposed to fire, in order to demonstrate whether it will withstand the impact and the sudden contraction of parts caused by the cooling effect of the water. The back of the furnace, with its complicated system of air and gas controls may be seen at the left

turers of fire-windows thought that no practical window, acceptable to architects, builders and owners, could ever meet Underwriters' Laboratories' requirements.

These requirements have never been made less severe.

Today, nearly one hundred manufacturers are making windows which actually do meet the requirements.

Before describing the tests to which various types of windows listed by the Laboratories have been subjected, it must be made clear that for *severe* exposures even the most fire-resistive window does not furnish sufficient protection because a window which allows a great deal of light to come into a room will also allow a considerable amount of heat to pass through its panes. Furthermore, even wired glass softens and falls out when subjected to sufficient heat. Therefore, Underwriters' Laboratories does not label windows for "severe exposure".

The label [it declares] is evidence of proper construction of the appliance at the factory. Prospective users should first ascertain from the inspection departments having jurisdiction which type, if any, of wired glass windows will be accepted in the location desired, and should make contracts subject to approval by them of the installation, glazing and automatic attachments.

Even where shutters are used, wired glass windows are usually needed. Shutter protection is either automatic or hand-operated. In the latter case there always exists the possibility of neglecting to close the shutter; in the former, some little time must elapse between the beginning

of the fire exposure and the automatic operation, and during that time the insufficient protection afforded by a wooden window with ordinary glass may spell disaster.

While the main classification of fire-windows is for "moderate" and for "light" fire exposures, the number of styles and combinations possible is very large, and the number actually manufactured under the Label runs into the thousands.

The testing of a fire-window contains some interesting features. When the many burners have been lighted and the flames begin to roar behind the translucent wired glass, there comes a series of reports, as a network of cracks begins to spread over the window. At this point the qualities of wired glass are apparent to the veriest layman, for the mesh holds the cracked panes tightly in place.

Soon the metal sash acquires a dull color and a strong radiation of heat comes through the glass. This radiation is tested by means of thermo-couples placed at various intervals and by strips of cloth hung before the window. During a test, one or more of these may take fire and fall to the floor, thus indicating that inflammable material may be ignited by radiant heat.

As the blue and golden flames play upon the inner surface, the metal sash begins to bend inward toward the heat until at length there is a pronounced distortion. Finally, after an hour's experience of this kind, the window is rolled back from the flames and played upon by a hose

stream, which causes clouds of steam to rise from the heated surface and soon tears gaps in the softened wired glass panes.

During all this time the engineers have been making careful observations and recording every essential fact.

4. Doors and Shutters

Under "Roofings" and "Windows" we have been considering protection against fires that attack from the outside, but this is the lesser part of the danger; in the great majority of fires the damage is done by flames that spread from room to room and from floor to floor *in the same building.* Confine a fire and you render it comparatively harmless. This is one of the chief objects of fire-resistive construction, which is aided by the knowledge acquired by Underwriters' Laboratories in its tests of materials and devices.

Among these tests, those of doors are of exceptional importance. An inside fire always seeks for openings, and all rooms must have doorways. An open door is an invitation to a fire as it is to a person, and many doors must be left open much of the time. This is a simple statement of a serious fire problem that has been responsible for thousands of deaths and has given rise to the large industry of fire-door manufacture.

Necessarily a door is part of a wall or partition, but it is a moving part and therefore must be light enough for easy

operation. In the case of a fire, it may be subjected to heat that will ignite the ordinary wooden door and allow the flames to spread on the other side. The duty of all fire doors is to resist such an attack but these are used under such a variety of conditions that a number of forms have been produced for the market. Many styles and makes have been tested and labeled by the Laboratories. These are grouped according to their use as : (1) "for openings in fire walls"; (2) "for openings in vertical shafts"; (3) "for openings in corridor and room partitions"; (4) "for openings to exterior fire escapes," and (5) "for openings in exterior walls"; this last class includes window shutters.

For Openings in Fire Walls. It occasionally happens that the fire wall in a factory or warehouse obstructs a raging mass of flame which must not be allowed to spread into the adjoining compartment. This exposure sometimes lasts for a considerable time and the wall's weakest parts, its doors, come in for a searching test.

Three general types for openings in fire walls are classified according to method of operation by Underwriters' Laboratories: the rolling type, the sliding and the swinging types, of which the latter two are considered jointly.

Rolling steel doors, as well as all other listed fire doors, are recognized as standard under the conditions of installation specified in Laboratories' publications.

In this category of doors, those "for Openings in Fire

Walls" are also the "Sheet Metal Fire Doors" and the "Tin-Clad Fire Doors with 3-Ply Wood Cores," with many makes and types listed under each heading.

For Openings in Vertical Shafts. Next in importance as safeguards to life are the doors "For Openings in Vertical Shafts." This does not mean that vertical shafts themselves are less important than openings in fire walls; fire usually spreads much faster vertically than horizontally. But whereas in the case of a fire wall there is but one opening to protect, in the case of a vertical shaft there are two, and one door will do for each. In other words, for a fire occurring on the sixth floor of a building, to spread to the seventh floor it will have to pass through one shaft door, travel up the shaft and pass through a second shaft door.

The doors in this group belong to the counterbalanced, rolling, sliding and swinging types and include steel, tin-clad, sheet metal, hollow metal and metal-clad paneled varieties. Each of these has its peculiar advantages and limitations, which are clearly shown in the reports and the great mass of information growing out of the Laboratories' thousands of tests is well worth the study of architects, contractors and building owners.

For Openings in Corridor and Room Partitions. Partitions used for the sub-division of fire sections of buildings are of considerable value in safeguarding life and preventing the rapid spread of fire through buildings.

As retardants, these doors need not possess the qualifi-

cations required for the protection of openings in fire walls, in vertical shaft walls or in walls of rooms containing specially hazardous processes, but they should be capable of furnishing a substantial barrier to the passage of fire, and should fulfill all service requirements. This last means a great deal, because these interior partition doors are very frequently used.

Many types and patterns of fire doors listed for protection of openings in fire walls or in vertical shafts are suitable for corridor or room partitions. These doors can be used in this situation, and Underwriters' Laboratories labels them accordingly.

While in the preceding classes, no glass is allowed, in this class standard wired glass is permitted, but the exposed area of individual glass lights must not exceed 1,296 square inches. The use of glass is, of course, a great convenience in this situation, but when equipped with glass panels, fire doors afford a limited resistance to fire and fire streams.

For Openings to Exterior Fire Escapes. Here we have special reference to the escape of people from burning buildings. This may take place under panic conditions and with but few seconds to spare. What then is the very first requirement for a door so placed?—undoubtedly, that it must be "capable of being readily operated from the inside of the building."

However, there are additional requirements. Such a

door is exposed to the weather and must not deteriorate for a long period. Furthermore, it becomes a part of the outside wall of the building and must protect its opening from outside fire exposure. "Only such fire retardants are included in this class," reads the official wording, "as have been shown by experience and tests to be capable of furnishing a *high* degree of fire protection against fire exposure where mounted on one side of the wall only."

For Openings in Exterior Walls. The final situation for fire doors includes fire-retardant shutters as well. Obviously, the protection furnished in this situation must be against external fires. In congested city districts or in other cases where the neighboring exposure is severe, this protection is of the greatest importance and bears on the fearful conflagration problem.

There is a large variety in listed fire doors and shutters for exterior walls, including some which are almost invisible when open and which can be used to protect the most beautiful building without marring its appearance. Several types are automatic; in general this implies a fusible link on the outside which melts when exposed to fire and allows the shutter to close. Some of the shutters have a "manual test release" which can be operated by the building superintendent on his periodic inspections, or by officials of the municipality or representatives of insurance companies.

From the foregoing outline of the many types of fire

doors listed by the Laboratories, it may readily be seen that the Laboratories' work, even though distributed over a number of years, has of necessity been intensive. It has resulted in a great improvement of all kinds of fire doors and shutters, and in the creation of new kinds.

Its effect has been particularly marked in relation to the widely-manufactured tin-clad doors, whose standard of construction is far more exacting today than was the case a few years ago; in fact, the earliest doors of this type showed so much distortion under the fire that they failed to cover the opening. Another difficulty was found in the puffing of the tin from the pressure of gases formed in the wooden cores. It finally was suggested that a circular hole be cut in the tin on the exposed side of the door. This proved successful; doors provided with such openings retained their shape much longer and, during fire tests, the gases could be seen bursting in a jet of flame from the hole.

Sometimes, indeed, the consideration of doors involves other phases than that of fire resistance. One incident is told at the Laboratories of a manufacturer who submitted a rolling door for outside installation in warehouses and barns. He was told that his outside door was all right save in one respect—it was not "sparrow proof". Taking this comment as a joke he disregarded it but in six months confessed his mistake, saying that he was beginning to receive many complaints because the construction permitted an opening which was promptly ac-

WORK THAT KEEPS INSPECTORS CONSTANTLY TRAVELING

Every labeled tin-clad fire door made in over 230 factories must undergo two separate inspections by the Laboratories' representatives: First the wood core is examined, and the final inspection covers the finished door. In addition the inspectors avail themselves of every opportunity to check up on processes of assembly. This inspector, for instance, is examining the workmanship and the construction of the seams in the tin covering of a door just being completed

PRESSURE UP TO 200,000 POUNDS

Everyone knows that there are many grades of concrete and the eye alone cannot judge of their strength. Here is a machine that cannot be deceived. The concrete building block, marked "B," is about to be crushed by powerful jaws, which are able to exert a gradually increasing pressure up to 200,000 pounds. Somewhere within this range the block will fail. This exact point will be noted by the engineers in charge, who will also report how the block behaved under the pressure

cepted by sparrows as an invitation to build their nests under shelter from the weather. The nest litter prevented the closing of the door and was an entirely valid point of criticism. This, however, is hardly a typical example.

A door opening, to be satisfactorily protected, should be provided with a labeled door, equipped with labeled hardware and mounted in a labeled frame, although, of course, labels may be applied to doors, hardware and frames separately.

5. Columns

Everyone who saw in the motion picture "news weeklies" the showing of the much-discussed Chicago fire of March 15, 1922, will recall the thrilling collapse of the Atlantic Building. First the walls began to fall from various stories, then the steel columns were seen to sag and, finally, what was left of the building went down while the spectators gasped.

Columns are among the most important elements in the strength of buildings, and the instance just cited is one of many in which the softening of iron and steel under heat has robbed them of strength and led to disaster.

Architects and engineers were long aware that fire protection called for some form of insulating covering for columns and various types were produced; but so many of these failed in use that there finally arose an insistent demand for exact knowledge. Tests made by several

organizations contributed some data but also indicated that their conclusions were incomplete because of inadequate apparatus. It came to be realized that in all the world there was no piece of apparatus equal to the tremendous task. Finally the job was taken in hand by Underwriters' Laboratories in coöperation with the United States Bureau of Standards and the Associated Factory Mutual Fire Insurance Companies.

During the years from 1912 to 1917, there was erected a huge combination of furnace and press, capable of taking a twelve-foot column, loading it with a 250-ton weight to represent such portion of a skyscraper as it might be expected to support, meanwhile surrounding it with a fire as intense as the fiercest conflagration. In connection with this extraordinary test furnace, there were instruments of delicate precision, for measuring and recording the loads sustained by the sample column, the temperature of the fire around it, the temperature *within* the column itself, the amount of sagging, bending and shortening under the influence of heat and pressure, and the distortive and, finally, the disintegrating effect of a fire stream of cold water turned suddenly upon the hot loaded column.

While the mighty machine was being built, representative types of columns and protective coverings were collected and during three years more than one hundred complete columns were thoroughly tested. The report

of these tests fills a printed volume of nearly four hundred pages.

The results of the work so far accomplished on columns may thus be summed up:*

The ultimate fire resistance of all representative types of building columns, when loaded and under conditions representing those of actual service in a fire, has been ascertained.

The relative resistance to fire of various materials and methods employed for protecting building columns has been determined.

A great body of reliable data has been provided by means of which the fire endurance of the various columns can be compared; and from this information it has been possible to do a great deal of grading and classifying of types of columns and methods of fire-proofing.

The effect of fire streams on heated columns has been ascertained.

Improvements have been developed in the fire resistance of the insulation and in the methods and conditions of installation.

One of the series of tests conducted by Underwriters' Laboratories alone is of almost dramatic interest.

The lumber interests had been greatly concerned over the apparently poor showing made by wooden columns, for "mill construction," when meeting certain require-

*See also Appendix xi, page 262.

ments, had always been regarded as better than unprotected steel of the same strength. Briefly stated, what astonished all experts was that certain types of wooden columns which were expected to bear a standard load while surrounded by a fire whose temperature was increased at a standard rate—and to bear that load for one hour before "failing," the definition of "failure" also being standardized and understood by all concerned—did not live up to expectations; they "failed" after about thirty minutes instead of one hour.

For two years beginning in 1919, further tests were conducted to find out what was wrong and how to correct it, and reports were made. The solution was elusive and was not reached until the fifth report.

In studying the results of the standard tests, it was readily seen that the wooden columns failed at the ends—never in the shaft portion. One phenomenon which might have passed unnoticed was given careful consideration; the end seemed to crush at first slowly and then much more rapidly. Now, this is the commonest of all phenomena in all tests of this sort, but it was decided to avoid the destruction of possible evidence and to study *what was happening during the slow deformation.* Therefore, a number of tests were stopped suddenly at various stages of deformation and, at last, after dissecting a number of samples and studying the appearance of the wood fibers, the cause was found. From the appearance of these fibers

at the very ends and at various short distances from the ends, it appeared that certain conditions of moderate temperature brought about an unexpected softening—indeed, an almost plastic condition of the wood at the end.

This overthrew current ideas, being a kind of "failure" which had never been predicted, and the next step was to find the remedy by devising an adequate *end protection.*

Various theories were tried out and abandoned. Finally experiments were conducted to determine whether a cap which would completely enclose the end of the column with insulating material would give better results, and of ascertaining the best design for such a cap. From the first, it was seen that this was the right direction.

At last, on October 30, 1919, a column failed under test —*not at the end but in the shaft portion.*

Now began a new series of experiments—on full-size columns, one foot square, just as are used in many buildings. With the experience previously gained, it was possible to determine just what to do to protect the ends of the columns, and the crowning result of all was a series of tests in which every column failed in the shaft portion —not a single end failure—and, what was most gratifying, the average time of failure was not one hour, which would have entirely satisfied the lumber people, but one hour and a half!

While certain supplementary applications are still under consideration, these tests have had the amazing result

of showing how the fire resistance of a wooden column may be increased two hundred per cent.

6. Walls and Floors

While structural engineers may consider a building to be a series of platforms enclosed by walls, a fire-prevention engineer is forced to regard them as large boxes in which people live, work or store goods, and which usually contain smaller boxes, called rooms. Everybody knows that boxes consist chiefly of sides and these, in the case of rooms and buildings, are the walls and floors. It follows that a building having a high standard of roof, windows, doors and columns may still be highly combustible unless its walls and floors likewise are fire resistive. Naturally these come in for constant study at Underwriters' Laboratories.

Again it must be emphasized that incombustible material is not necessarily fire resistive in use—*it must be rightly used.*

A single brick may survive a very hot fire for a considerable length of time, but a wall made of such bricks may be constructed so poorly that it will not stand up under a typical fire. Another wall, constructed of materials which are able to withstand high temperatures, may lose so much strength under fire that it will no longer support the floor beams. Some walls make a good showing while fires rage against them, only to crack and crumble when struck by the firemen's hose stream.

At the instance of manufacturers of various materials and of associations and official bureaus, Underwriters' Laboratories is conducting a great number of tests covering types of walls and partitions. Most of this work has not been for the labeling of products, but in the nature of research and classification of familiar types.

Investigations of the fire resistance of building materials have been conducted in Europe and America for more than half a century, by official bodies, architectural and engineering societies, and a great number of commercial bodies and individual firms. The total amount of work performed by Underwriters' Laboratories on the subject of walls, figured in total hours, represents but a small fraction of the whole, but it has proved to be the most important and authoritative.

It will no doubt take several years to complete the classification of walls with regard to fire resistance, strength and fire-hose-stream resistance. Already, a number of types of construction have been classified. That is to say, it is possible to know in advance just how long they will endure in a typical fire before "failing"—the expression "failing" being well defined.

In the field of walls and interior partitions of lesser strength and resistance to fire, the Laboratories has achieved noteworthy results, and it is now possible for the architect to give his client definite assurance as to the performance of listed materials.

With regard to floors, the problem has been somewhat different because the floor structure of one story involved the ceiling of the story below. Therefore, the chief work of the Laboratories has been not so much that of testing the highly resistant types as of determining the retardant value of ceilings of various fire-resisting materials applied under wooden joist construction, as in frame houses.

The intensely practical nature of the investigation is shown by certain tests that were made in April, 1922. The War and post-war conditions had resulted in a great scarcity of buildings, particularly of dwelling houses. The cost of materials and labor had checked construction, and rents, in consequence, had risen to alarming heights. Newspapers were full of the discussion; it had become a sociological question of the first rank, affecting as it did the living conditions of millions of people.

There was an urgent demand for hundreds of thousands of inexpensive new houses, *but* the building codes of the various cities very properly forbade the increase in conflagration hazard that would have come from the usual type of cheap construction.

Here was a serious problem which the Laboratories tackled from an interesting angle. Accordingly, in April, 1922, a number of people were gathered in one of the furnace rooms to witness tests that might prove to be of far-reaching importance.

A section of partition had been inexpensively con-

THE EFFECTS OF CORROSIVE AGENTS

The durability and reliability of automatic sprinklers may be seriously affected if they become corroded after installation in a building. In this picture sprinklers in the covered glass vessels are being tested in corrosive gases in order to determine their ability to withstand such action. (See p. 50)

OXY-ACETYLENE WELDING SECTION

Welding is required in some of the operations of the Plant Department and an oxy-acetylene torch is in frequent use. The operator here shown is wearing goggles that have been tested and approved by the Casualty Department (See p. 201)

structed by nailing metal lath to both sides of wooden studding and coating the surface with gypsum plaster. This partition was installed in the front wall of the great vertical furnace adapted to such use and subjected to the fierce intensity of gas flames under prescribed conditions.

At the end of the period, the partition was rolled from the furnace and its glowing surface received the full impact of a fire stream as might be the case in a real fire. Naturally the power of the stream tore the plaster from the lathing, whereupon it was discovered that the wooden framework beneath had been so well protected as to have suffered less than ten per cent. impairment. In other words, such a partition would have remained relatively good after passing through a one-hour fire of more than ordinary intensity. It was not to be considered "fireproof", of course, but it would serve as an efficient fire barrier for a period of an hour.

Tests of a floor section of the same general type were made in a horizontal furnace and gave equally good results. In this case the test included loading the floor with weights and taking observations to determine whether there were any sagging beneath the load under the influence of the fire.

The imaginative spectator could easily let his mind travel from the technical atmosphere of such tests and see them in their ultimate human relations. He could picture the construction of great areas of workmen's cot-

tages where cheap construction made low rents possible and furnished safe and satisfactory living conditions within the reach of small incomes. Such savings in turn translate themselves in terms of bank accounts, contentment and social security.

Doubtless one must check the play of his imagination within moderation, but doubtless, also, it is true that the heat waves of the testing furnaces at Underwriters' Laboratories set in motion impulses of sociology, economics and human welfare that travel far.

CHAPTER TEN

Safeguarding "The Universal Servant"

1. The Universal Servant

ELECTRICITY has earned the title of "universal servant." It seems futile to attempt to fix the boundaries of its human service, for these change almost daily. Within the memories of those who are not yet old, it has been viewed first as the subject of interesting laboratory experiments, then, successively, as an agent for transmitting messages, for conveying speech, for producing light, and for furnishing power to be used in transportation and industry. Today it is a household helper, for which uses are announced almost daily, it has a definite place in surgery, and recent investigations into radio phenomena suggest further possibilities of immeasurable value.

Electricity defies limitation, as it still defies definition. Every individual in the land is directly or indirectly dependent on some phase of electrical application during almost every day of his life. He utilizes it in his telephone calls, his lights, his transportation, his elevator service; while even the food that he eats and the clothes that he wears probably have involved the use of electricity at some stage of their preparation. This intimacy and universality

of service make it a matter of deep public concern that the myriad devices and materials through which electricity is applied be rendered efficient and safe.

As is natural under the circumstances, the last generation has seen the growth of a very extensive industry which may roughly be sub-divided into the *production*, the *distribution* and the *installation* of electrical supplies and which therefore includes the manufacturer, the jobber, and the contractor. Closely related to these groups are the regulatory authorities and, finally, the user whose money supports them all.

The work of Underwriters' Laboratories has become virtually an integral part of the electrical industry; it exerts a direct influence upon each of the classes mentioned.

2. *What Is the Relation of the Laboratories to the Electrical Industry?*

The relation of Underwriters' Laboratories to the electrical industry is essentially one of service to manufacturer, jobber, contractor, regulatory authority and user. It also furnishes a common meeting ground for the discussion of questions, tendencies and developments that are of interest to them all. The nature of this service will become apparent in an analysis.

First, as to the manufacturer: The highly technical character of production in the electrical industry makes the fixing of standards a matter of peculiar importance.

Appearances count for so little, and design, workmanship and materials for so much that the layman's judgment is practically negligible. Consequently, there is a large opportunity for manufacturers to bring discredit upon the entire industry by means of inferior goods. Such goods, marketed at the lower prices made possible by their character, would exert a demoralizing influence on the industry were this not powerfully counteracted.

The chief means to this end consists in *the fixing and maintenance of standards of quality* supported by construction and service tests and by manufacturing inspections. In this work, the Laboratories coöperates with the manufacturer as an individual and with his trade and technical organizations. These standards, therefore, are the product of joint effort to which the manufacturer is himself a party; they stipulate certain *minimum requirements*, but in no wise limit maximum achievements, and they are not left to shift for themselves but are rigidly maintained through a comprehensive inspection system. As a result the electrical industry is equipped with standards of safety and performance to a degree that would amaze a layman.

Underwriters' Laboratories has separately examined, tested and reported upon *more than thirty-five thousand* different makes and styles of electrical appliances—always at the request of the manufacturers themselves—and its inspectors make frequent visits to many hundreds of factories.

Second, as to the jobber: With this class, the relation is

very different. The electrical jobber may not be familiar with the technical values of the goods he sells because such knowledge may not be essential to the making of sales. As a matter of fact, he is in position to shift responsibility on the one hand to the manufacturer who produces these supplies and, on the other, to the contractor who installs them. His particular interest is in *saleability* and, having found that goods bearing the Laboratories' label are more saleable than others, he naturally prefers to handle them. He has learned to "*look for the label*".

Third, as to the contractor: The contractor is the jobber's chief customer and the man whose work is under inspection. His principal contact is with the owner to whom he is much closer than is the jobber and whose interests he must serve because improper installations may not only result in unsatisfactory conditions of use but may also interfere with the owner's safety and his ability to obtain insurance at the best rate. Therefore the contractor must comply with the provisions of a code that is very explicit as to the standards of materials to be employed, and these standards are assured to him by the Laboratories' label. He knows that the municipal inspector and the insurance inspector will look for the label. This is why the jobber finds it easier to sell labeled goods.

Fourth, as to the inspector: The inspector must review the work of the contractor. He bears a large measure of

responsibility because the standing of the installation as to its safety and the insurability of the building depend on his verdict. He is familiar with the regulations and is able to judge of installation work, but how shall he judge as to the character of the materials employed? These materials may easily have important defects of which he has no technical knowledge.

He can tell how a wire should be put into a house but cannot determine the quality of the rubber that is used in its insulation. He can specify whether there should be a switch or a fuse but is unable to judge the character of a *particular* switch or fuse—whether it is a trustworthy device or a source of danger to the building's occupants. Such things can be determined only by means of adequate tests and the average inspector has not the time for making tests, the laboratory in which to make them, nor the experience and special training required to give them value.

The inspector, therefore, is glad to throw all responsibility in the matter of materials squarely upon Underwriters' Laboratories by whose rating and label he is guided.

Lastly, as to the user: At least three of the preceding classes must have some degree of technical knowledge; not so the user. In order to be able to pass on the character of the supplies installed for him by the contractor he would have to become an expert judge of such varied arts as those which concern the production of yarns, waxes, rubber, brass and copper goods, automatic machine products,

porcelain, molded insulations, electrical control of machinery, all the hazards to persons that may be involved in electrical devices and many other things. Obviously, he can at best traverse but little of this vast field of complicated technical understanding although his own welfare, perhaps his own life, may be concerned in it.

Exactly such things as these are made the subject of minute investigation before labels are awarded by the Laboratories to the goods that the contractor buys and installs. Therefore the relations of that institution to the millions who employ electricity is vital and constant although generally unrecognized by them.

3. The Practical Viewpoint

As soon as we leave the field of generalities and attempt a closer view of the Laboratories' investigations of electrical materials and appliances, we are struck by the enormous detail and complexity involved. While electricity is fascinating on its purely scientific side, the Laboratories' work is controlled by a severely practical viewpoint. It may think in terms of general laws, but it deals with specific materials, and it must always consider these materials *as they would be found under the conditions of actual use.* Moreover, while the investigators frequently are able to make suggestions that increase the efficiency of the product under test, such suggestions are merely incidental; their main concern is with *safety in use.*

HIGH POTENTIAL TEST OF AN ELECTRIC WATER HEATER

One of the things to guard against in electrical appliances is a possible failure of the insulation which may make the frame "alive" and shock any one touching it. This engineer is therefore subjecting a domestic water heater to a voltage far above what it would receive in service. Incidentally, the engineer himself and other persons are fully protected, because all high voltage parts are in the glass-walled enclosure the doors of which are interlocked with switches that are "on" only when the doors are closed

TESTING ARMORED CABLE

Armored electric cable is in almost universal use to-day, and its tests include determination of tension and elongation in order to learn how tightly the conductor is held in the armored casing. The sample shown is being subjected to an elongation test by means of a 100-pound weight, and it is required that the armor shall not show a permanent elongation of more than three inches in a three-foot length, after one minute of this tension.

What then is the experience of an electrical appliance that has been submitted for test, rating and possibly label? In thousands of cases it is required to make answer to five searching questions:

First: Is it suitable for the use intended and can it be properly installed?

Second: Are its mechanical strength and durability adequate?

Third: Is it provided with satisfactory insulation?

Fourth: Is it free from liability to dangerous heating?

Fifth: Has the danger of "arcing" been provided against?

These questions are asked not verbally but by means of various kinds of scientific apparatus under the control of electrical or mechanical engineers or chemists.

First: As to suitability: For example, a given switch may be suitable on a lighting circuit but not to control a motor, or it may be a good switch by itself but have no proper means for connecting it to wiring or conduit or for enclosing its dangerous parts.

Second: As to mechanical strength: For example—how strong should be the metal armor of a 2-conductor No. 14 gauge armored cable? The Laboratories' Standard is specific. It says:

The armor must be of such design that it will not open at any point after having been subjected for one minute to a tension of 150-lb. on a 3′ length. This test to be made with the conductors removed from the armor.

There follow several more paragraphs which leave no room for misunderstanding, and there also follow minute specifications as to the testing apparatus and procedure. All these precise requirements are involved in answering the simple question: How strong?, for in no other way could the *unvarying uniformity* of the tests be assured.

Third: As to insulation: The question of insulation is always vital in considering the application of electricity. Defective insulation that permits "leaking" naturally reduces the efficiency of the appliance, but (and this is the especial concern of the Laboratories) it also permits the escape of the current in ways that may be of hazard to life and property.

It may be added that, whereas fires of unknown origin commonly used to be ascribed to "defective insulation," this custom has practically disappeared. The Laboratories has exerted a powerful influence in bringing safety into insulation during recent years.

Fourth: As to heating: One of the large values of electricity is its convertibility into heat, but this also constitutes one of its chief dangers when such heat is undesired or excessive. Thousands of fires each year are traceable to overheated electrical appliances. Therefore, one of the principal questions to be asked of any product coming up for inspection concerns its liability to develop heat in use. For instance, the Laboratories, in 1918, conducted an extensive investigation into the minimum cross-

sectional area to be required in certain small parts of plug fuse bases in order to prevent their becoming unduly heated and thus causing inequalities in the performance of the fuses.

Fifth: As to "arcing": The liability to permit an electric arc that is not part of its purpose, is a serious indictment against any device. Such an arc coming in contact with inflammable material may cause a fire, or, if it reach explosive vapor or dust, a severe explosion may result. Many disasters have been caused in exactly this way, and the investigator is required to consider all the conditions under which an unexpected arc may be formed.

In other cases the formation of an arc is an unavoidable feature of the operation of a device and this fact calls for special safeguards.

The device that has successively and successfully withstood thorough scrutiny as to its suitability, strength, insulation, and heating and arcing characteristics, may be considered relatively free from hazard, whatever may be its efficiency in the use for which it was designed. It is, perhaps, natural enough that the inventor, and, to some extent the manufacturer, should be so engrossed with the effectiveness of a product as to give little thought to its freedom from hazard. The average purchaser cannot judge the degree of hazard even when his attention is called to the subject, but the insurance company that assumes the financial risk of indemnifying a loss that may be caused by such a product cannot afford to guess at its

liability to create hazard. Underwriters, therefore, give careful consideration to the presence or absence of the label that certifies the tests.

4. The "Worst Treatment" Test

The thousands of electrical devices and products which are submitted to Underwriters' Laboratories for test and rating may for convenience be divided broadly into three groups, as follows:

First: Those materials that are purely electrical in their function, such as wires, cables, conduits, switches and the other devices for which there are printed or mimeographed standards.

Second: Miscellaneous devices primarily electrical in their operation, such as heaters, smoothing irons, etc.

Third: Miscellaneous devices that employ electricity incidentally, such as electric pianos, vacuum cleaners, washing machines, and many others.

The first group naturally requires thorough examination, and tests representing the most severe conditions that might be encountered in actual service; the third group requires little more work than that of making sure that its electrical parts are standard, and that it is suitable and well made; but, between these two extremes, there comes a long list of devices calling for a wide diversity in examination and test. In this class new problems are frequently encountered and it becomes necessary to devise

BREAKDOWN TEST OF RUBBER-COVERED WIRE AT FACTORY

Many coils of wire taken from the manufacturer's stock are immersed in the steel tank and an electric pressure of 1500 volts A. C. is applied to all simultaneously. It is obvious that the slightest crack or electrical defect will allow current to flow. If it does there will be violent bubbling of the water. This very rarely happens, for the simple reason that the manufacturer's own routine inspections include tests similar to those made by this Laboratories' inspector

MEASURING THE ACTUAL RESISTANCE OF WIRE INSULATION

In this view a Laboratories' factory inspector is shown making measurements of the insulation resistance of coils of rubber-covered wire which he has selected from the manufacturer's stock. This is not a breakdown test to determine what electric pressure is required for a current to rupture and jump through the insulation, but is an actual measurement by means of exceedingly delicate instruments of the infinitesimally small current which leaks through insulation (no matter how high-grade it may be)

new testing methods. To illustrate the practical spirit of these investigations, take the instance of a wash-room device which throws out a blast of hot air for the drying of hands and faces. This being a new device, the engineers had no comparative data as to its purely electrical features but these were found acceptable after simple tests, one of which was to tie down the foot-switch so as to represent somebody accidentally placing a box or bucket on it and then going away and leaving the current on. The result indicated that near-by combustible materials would not be ignited through overheating under such conditions of misuse.

Outside of purely electrical tests, however, it was necessary to make others, such as the "marble test," representing the placing of small objects in the orifice of the machine by mischievous boys. As a result the manufacturers made certain modifications and expressed appreciation of the Laboratories' practical viewpoint.

The "marble test" just referred to is representative of a test principle that is applied to most electrical appliances, and may be called the "worst treatment test". This means that particular attention must be paid to the *abuse* as well as to the use of a product. Its hazard must be determined in the hands of the careless or unskilled people who form so large an element of the public. It is important therefore that a device be made as nearly "fool-proof" as possible.

In a motor-driven device, for example, the *worst treatment* that the motor can receive is that of being stalled with the current on. Accordingly the engineers reproduce this condition in order to observe results, particularly as to whether near-by combustible materials are likely to be ignited. Of late, there have appeared several automatic water heaters of the faucet type. The *worst* thing that can happen is for the water supply to be interrupted while the current is on. This, too, is forced to take place under the eye of the testing engineers and the results are noted. Again there is the safety viewpoint. In the automatic water heaters just mentioned the *worst* feature from the standpoint of accident prevention is found when there is a possibility that the outer metal parts or the water stream itself may become "live," and the examination and tests are devised accordingly.

5. *Rubber, or What?*

The electrical tests of Underwriters' Laboratories are of such number and interest that volumes would be required to do them even approximate justice. In the limited space at our disposal a closer glance can be taken at but one or two, and among them all nothing is more important than the testing of rubber-covered wire, of which familiar commodity, literally millions of miles have been produced.

Nevertheless, the term "rubber" is not so simple as it

sounds; it is applied to a wide diversity of products representing many differences in the natural gum, many diversities in the formulas and processes of manufacture, and a wide range in the use of adulterants. These conditions have resulted in some products that are excellent for use in insulation, and others that are conspicuously unfit. As is so often the case in the electrical field, differences of quality may not be apparent to the eye, but can be learned only by means of exacting tests.

Take, for example, the tests of insulation on that popular size of rubber-covered wire known as "Number Fourteen." Everyone is familiar with this material but few have any conception of the ordeal to which it must be subjected before being awarded the coveted label. Before it can qualify, it must stand up before its judges and give satisfactory answers to such questions as these:

What is the exact diameter of your copper wire?

Is the copper well centered in the rubber?

Is your rubber wall at least three sixty-fourths of an inch in thickness?

Has your outer covering of cotton braid the proper thickness?

Is it of the proper workmanship and is its weave sufficiently close?

Has it received proper saturation?

Are you able to withstand a reasonable amount of bending back and forth?

What is the quality of rubber used in your insulation?

Will it withstand the prescribed stretching tests as to elasticity, elongation and strength?

How about the chemical tests of your rubber? What will they tell us as to acetone extract, alcoholic potash extract, chloroform extract, ash content and sulphur content?

What is your current leakage when immersed in water?

The answers to these and other questions require the use of various forms of apparatus and the most intensive study. To give the briefest accurate description of the procedure and apparatus in the chemical test alone would require more than ten pages. Yet there is nothing superfluous about them, because wire of this nature is the familiar pathway of man's "universal servant," and unfaithfulness on the part of testing engineers might permit this servant to slip from its pathway and use its terrible strength for destruction.

Even after such questions as those cited have been satisfactorily answered and the label has been awarded, similar examinations and tests are repeated frequently on samples taken at the factory by the Label Service Department inspectors, on samples purchased from stock offered for sale, and on installation samples secured from buildings throughout the United States and Canada.

Taken all in all, the Laboratories' influence has been steadily directed not only toward the improvement of materials used for ordinary wire insulation, but, what is

SEARCHING OUT THE QUALITIES OF RUBBER INSULATION

The "rubber" insulation of electric wire contains substances other than rubber; the Laboratories insists that it should possess a number of qualities. One of these is "life" and the assistant in the background is observing the degree to which a sample springs back to size after being stretched. The operator in the foreground is separating the insulation from the copper conductor by stretching the latter until its diameter is reduced sufficiently for the "rubber" to be slipped off

PHYSICAL TESTING OF RUBBER

The sample of insulation from an electric wire, shown in a preceding illustration being prepared for a physical test. Here the operator is measuring the distance between the white marks, in order to note the number of inches to which the rubber stretches before it is forced to snap. The operator at the other machine is reading the dial of a strength-testing machine which stretches a sample at a predetermined rate. On the table are other samples to be tested

at least as important, toward the constant, systematic and efficient maintenance of standards of quality by means of adequate and persistent testing. The resulting increase in public safety can hardly be overestimated.

6. *The Electricity of the Skies*

While the word "electricity" is derived from "electron," the Greek name for amber, because the scientifically-minded Greeks had become interested in the electrical phenomena that are produced when amber is rubbed, mankind throughout most of the ages of the world has known nothing of electricity, save as it has been seen in the lightning's flash. In all lands, it has been the subject of superstitious awe and terror. Its destructive power has been an attribute of the gods. It has been the bolt in the hands of Jupiter Olympus or the flashing hammer hurled by the savage Thor, working annihilation where it has struck.

The destruction wrought by lightning still continues on a vast scale—so much so that millions of dollars are paid in lightning insurance each year. Not long ago an investigation into the cause of some forty thousand rural fires showed that more of them were caused by lightning than by all other causes combined; yet this same investigation furnished the interesting information that not one of these fires had involved a building that was properly provided with lightning rods.

Thus the subject of lightning rods has become an important consideration of public safety and an item of concern to insurance companies, particularly in the country districts. As such, it is a natural subject of interest to Underwriters' Laboratories, where its investigation practically reverses the viewpoint of most of the electrical tests: Here the purpose is not that of creating, directing or applying the electrical current, but of diverting and dissipating it.

One might be inclined to believe offhand that tests of lightning rods presented a very simple problem. Simple in appearance as they may be, they involve a great deal of work on the part of the Laboratories, which maintains a staff of traveling inspectors to report on installations.

It must be borne in mind that lightning rod equipments are purely electrical, even though they are not wiring devices. The Laboratories has a printed standard for their construction and installation, which is over sixty pages in length; goes into the details of thorough examinations and tests of the materials employed; specifies the metals, weights, sizes and shapes of conductors, terminals and fasteners for structures under sixty feet in height, those from sixty to one hundred and fifty feet, and those over one hundred and fifty feet; describes proper installations for various forms of buildings, roofs, steeples, smokestacks, tanks, etc., and describes the two-fold label

service procedure—consisting of inspections at factories and reports on labeled installations.

This last feature is very interesting, in that it requires two successive reports: first, one from the manufacturer of the materials employed in the installation, which must be made out within thirty days after date of installation; second, a report from a Laboratories' inspector to whom the manufacturer's report and other information has been referred; the latter not only verifies the first report but checks up the workmanship of the job, examines bends in conductors for cracking or flaking of the protective zinc coatings, notes whether provision has been made to protect ground rods so located as to be subject to injury or displacement, makes sure that large metallic objects within the buildings are grounded, does the same for metal fences attached to buildings, and makes recommendations.

When it is found that the Laboratories' requirements for standard installations have not been complied with in all essentials, the manufacturer is notified and must make the necessary corrections within thirty days. He then notifies the Laboratories, which arranges for re-inspection —at the manufacturer's expense.

7. *"Economy" vs. Safety*

It has already been stated that the electrical industry is subject to the intrusion of those manufacturers who are willing to sacrifice quality to price, and the layman, in-

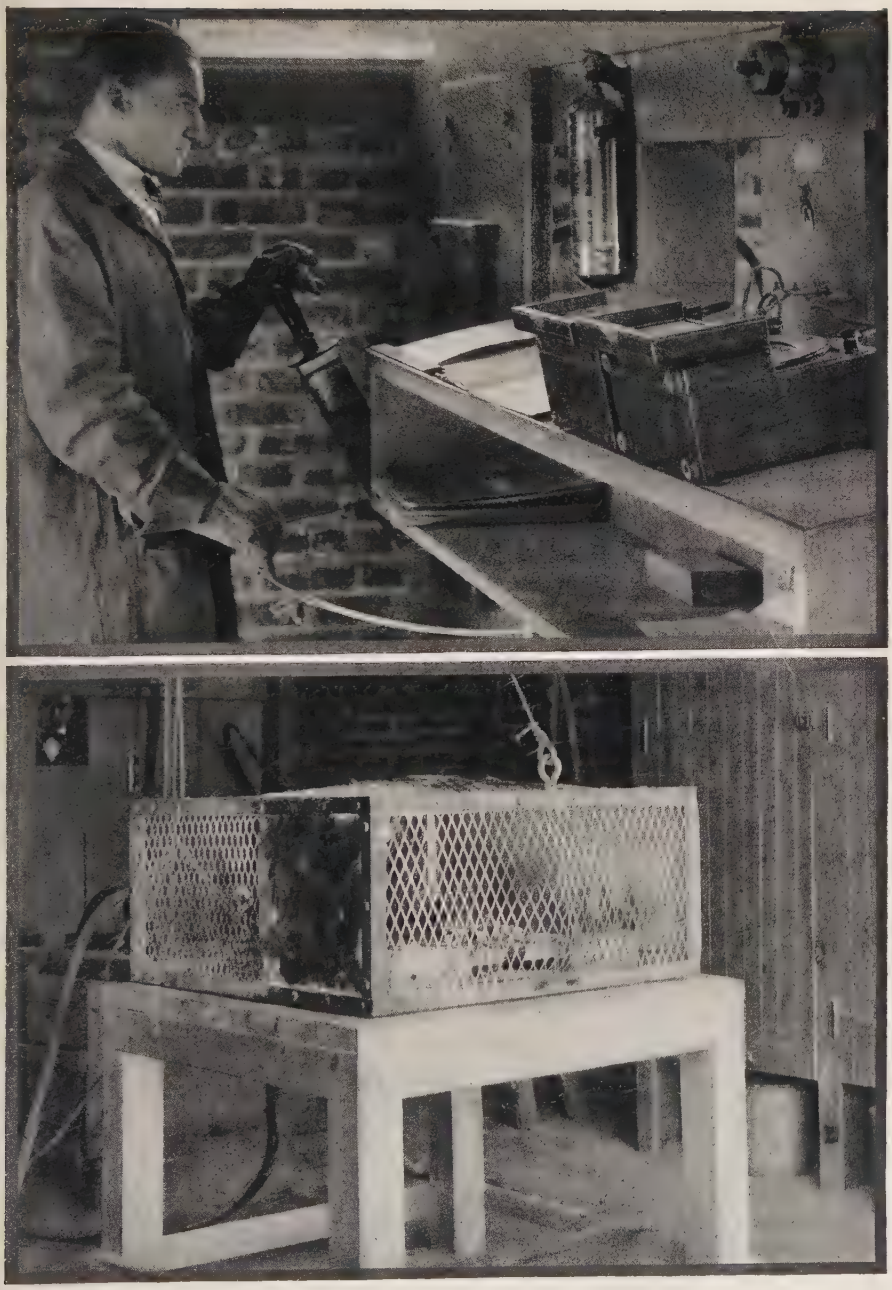
capable of exercising judgment in such a technical field, must depend upon the expressed opinions of others although his own safety may be at stake. As previously explained, the severe tests of thousands of electrical products conducted by the Underwriters' Laboratories, and the use of the label to certify these tests to the public, have constituted a safeguard recognized both inside and outside of the industry as a means for maintaining its standards and increasing its efficiency. They have aided the better class of manufacturers in their efforts to eliminate the unfit.

As a single extreme instance of the need for eternal vigilance, there was placed upon the market an "electrical toaster" of which its manufacturers doubtless expected a large sale, as it was capable of being offered to the public at the low price of ten cents. In order that it may be realized what would have been their effect on public safety, several passages from Underwriters' Laboratories' report are cited:

AN ELECTRIC TOASTER FOR TEN CENTS

* * * * * in which the amount of material is reduced to a minimum and the construction to the simplest form. * * * * * horizontal type and is simply a rectangular sheet-metal frame supporting several wires across the top, spaced about 1½ inches apart, and a length of resistance ribbon terminating in a pair of ordinary dry battery binding screws and looped between two narrow strips of asbestos board. The device consumes 580 watts on a 110-volt circuit.

* * * * * Among those hazards may be mentioned the exposed and unprotected heating elements; lack of protection from heat



SHORT CIRCUIT TEST OF A LARGE FUSE

Protected by a cage and a partition, this engineer observes the fuse in the former through an opening in the latter, and is about to "throw a dead short" by closing the switch with his left hand. In the event of a disastrous failure of the fuse he can clear the circuit immediately by yanking the rope operating a large toggle switch. Photos taken at the Laboratories' fuse testing station near the Kingsbridge (N. Y.) substation of the N. Y. C. R. R.

TESTING A SMALL ELECTRIC LIGHTING PLANT

Thousands of farm houses and suburban homes are employing individual electric lighting plants, wherein an internal combustion engine drives the electric generator which furnishes the current. Such plants call for a wide diversity of tests as to a number of features. In the picture, the engineer is using a tachometer to record the speed of the generator, and determine whether the electric windings overheat

* * * * * surface under the toaster;* * * * * liability of loose strands of the supply wires coming in contact with and making the frame "alive," and the use of supply wires having insulation not designed for electric heaters.

There follow the disastrous results of tests under conditions representing actual service in a home, concluding as follows:

With the toaster placed on a plain uncovered pine board, with a square of sheet asbestos where a slice of bread would be placed, flames enveloped the toaster in six minutes.

In the 25 minute period over which the foregoing tests were continued, the insulation * * * * * adjacent to the terminals was entirely destroyed by the heat for a length of about two inches * * * * * so that the bare strands of *both* wires could come in contact with the edges of the frame of the heater.

Such a "ten-cent" toaster might easily result in a fire costing thousands of dollars to its user.

Similar conditions in greater or less degree are found in numerous other products. There can be no true economy apart from safety, and the label which spells safety is a servant of genuine thrift.

8. The Growth of the Electrical Department

The foregoing sketch gives but a brief and inadequate glimpse of a work of great scope and complexity that engages the entire time of a number of engineers.

It has already been told (Chapter Four) how Underwriters' Laboratories originated in the establishment of facilities for making simple tests of electrical materials

at the time of the World's Fair in Chicago. From that time to the development of the present many-sided institution, this department has held its place as one of the most extensive and important of all the divisions of work undertaken. The growth, however, has been intensive as well as extensive, and is sometimes misunderstood by those not familiar with its genesis and reasons.

It must be remembered that this development has not been in the nature of a restraint imposed on the electrical industry from without but is the result of a process of evolution, both internal and external.

For more than a decade before the establishment of the little Monroe Street testing shop, there had existed rules intended to insure safety in the use of electricity and these, in turn, were the result of the growing number of fires that were electrically caused. Gradually it came to be realized that the reduction of this hazard must be based upon the possibility of specifying the use of electrical goods of *known* characteristics, of *uniform* quality and according to *uniform* rules.

The New York Board of Fire Underwriters was the first to issue a printed set of rules to this end, a brief circular, placing great reliance upon the judgment of "surveyors" and the "Inspector". The first printed set of rules of national application was issued by a joint conference of insurance and electrical industry representatives, known as the National Electro-Insurance Bureau. This was in

1891 and the title was "The National Code of Rules for Wiring Buildings for Electric Light or Power."

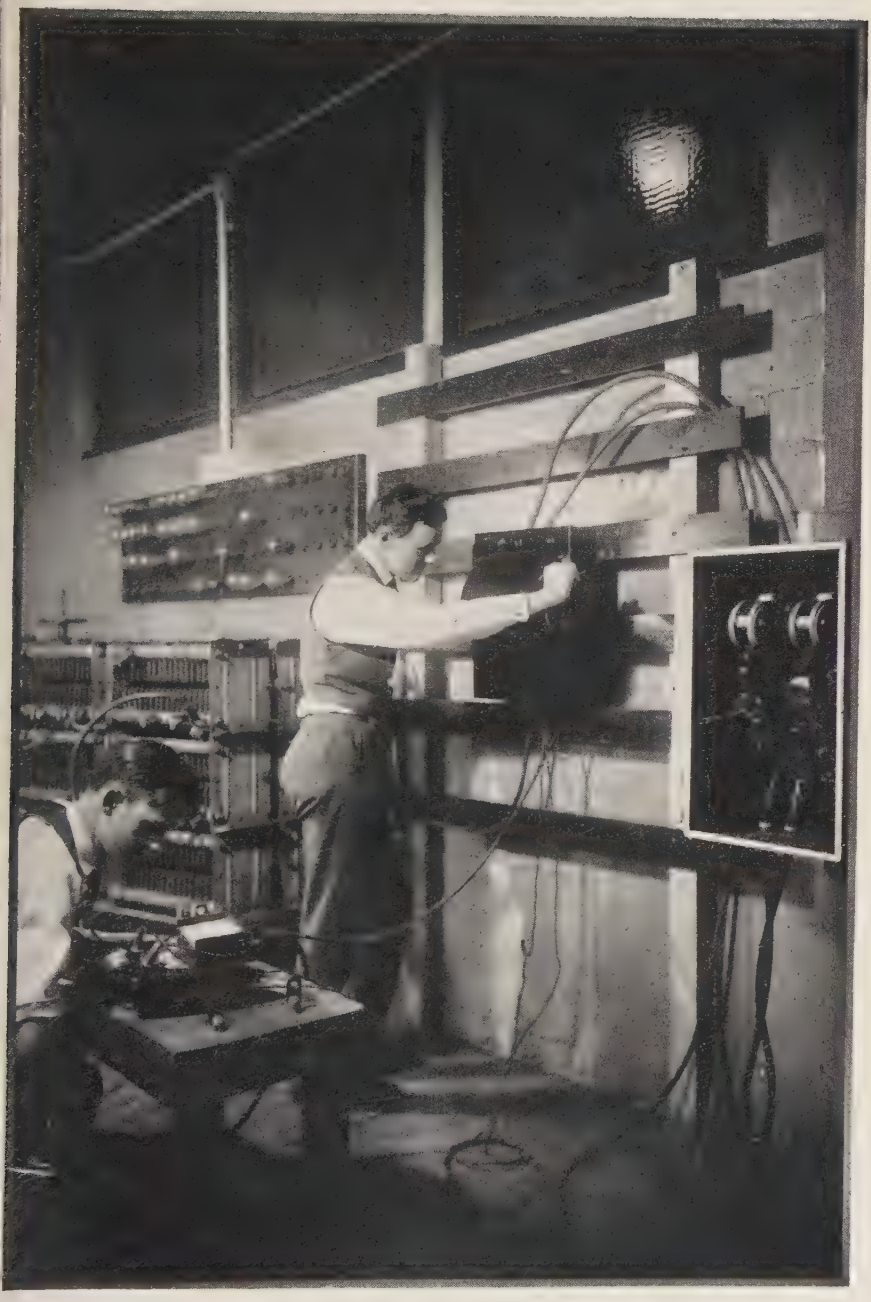
It must not be imagined that the promulgation of that first national code was really effective. Far from it! Even today, in spite of the admirable National Electrical Code issued by the National Board of Fire Underwriters and constantly revised by the National Fire Protection Association, which is a federation of over 130 associations, industrial bodies and governmental bureaus, uniformity of regulation has not yet been achieved throughout the states or even throughout the various counties and townships of some individual states.

A glimpse at the situation existing just prior to the inception of the laboratory work is given in the following quotation:

> Early in 1892, Secretary C. M. Goddard of the New England Insurance Exchange suggested a meeting of electrical inspectors of several underwriters' organizations to consider uniformity of rules. This meeting, held in August of that year, carefully considered this code, section by section, in order to make such changes as the experience of the insurance inspectors indicated were necessary in the interest of the insurance companies.
>
> This effort for uniformity of insurance rules was so successful that another meeting was held in December of the same year, to which the inspectors of all insurance boards in the United States and Canada were invited. At this meeting a permanent organization was effected and an Electrical Committee appointed, whose duties were to be (*a*) the care of the rules, (*b*) the making of tests, and (*c*) the giving of information and advice to members.

Here, then, were two interests, both of them sincerely desirous of promoting safety in the use of electricity, but approaching the problem from different sides. The electrical industry was dependent for its growth on public favor which was imperilled by all evidence of hazard, and had the best of reasons for wishing to eliminate such hazard. The insurance companies on the other hand had come to regard electricity as a possible source of fire and therefore were forced to study its elements of fire danger. The growth of the use of electricity thus produced a situation that, in 1893, found expression in the establishment of a tiny station for testing electrical supplies in behalf of the underwriters. As a matter of fact, had not the genesis of Underwriters' Laboratories occurred in just this way, some institution resembling it would doubtless have grown from some other acorn. It was a manifest necessity.

There were, of course, large possibilities of clashing through mutual misunderstanding had the original encounter been unsympathetic. However, the spirit of the Laboratories' work was shown at the outset when Mr. Merrill approached the manufacturers with the request: "Tell me about your problems. I want to know. Tell me about your tests. I want to know what you consider fair. I want to learn your own ideas about minimum requirements and about inspections." Thus were born the Industry Conferences that have played so large



PERFORMANCE TEST FOR ENCLOSED SWITCHES

The protection afforded by enclosed switches is so important where electricity is used to any large extent, that a number of makes are on the market. One of them is shown receiving a performance test, in which the load is adjusted by means of a bank of resistance grids shown in the background. The casing of the enclosed switch is effectively grounded during the conduct of these arcing tests, reproducing the same conditions that would be found in service with conduit connections

A TEST THAT MEANS SIXTEEN YEARS OF USAGE

If you use an electric lamp every evening for sixteen years you will have worked the switch about twelve thousand times. This machine operates key sockets, pull-chain sockets, push button switches, surface snap switches and other such devices, at the rate of about twenty snaps on and off per minute, while current flows through them and lights the lamps. The switches must complete six thousand cycles of operation and still be serviceable mechanically and electrically

a part in the electrical activities of Underwriters' Laboratories ever since.

Today, in spite of occasional differences of opinion, the growth of the work has been characterized by a really remarkable spirit of coöperation in which the attainment of standards has been *registered*, rather than forced. Every organization having anything to do with electricity has contributed its share to the growth of Supervision, Regulation and Education with regard to the manufacture, installation and use of electrical appliances.

This has involved the development of the famous National Electrical Code of installation rules, or the "Fire Code" as it is frequently called, and also the National Electrical Safety Code, bearing on safety from accident rather than fire. While the Laboratories' staff has been intimately associated with other bodies in the development of both these codes, their discussion lies outside the province of this account.

Supplementary to these, the Laboratories has gradually evolved a great accumulation of detailed rules governing its own requirements and work on electrical appliances—always in conformity with national codes. These rules are known as standards. For instance, there is the Standard for Snap Switches, which is printed; other rules are mimeographed; some, as in the case of new products, are typewritten documents of which only five copies are filed. All these rules have been systematically arranged and codi-

fied, and they now form part of a third code, which, while of national application, is not called National in order to avoid confusion. It is the *Underwriters' Laboratories' Code of Standards for Construction and Test of Electrical Appliances.* For the sake of convenience, this body of rules is generally known as "The Standards".

Volume One of the Laboratories' code of standards is a thick book of over 500 loose-leaf pages. It consists only of the wiring device standards which have been *printed.* These naturally govern the subjects on which the most work has been done—products that have become the recognized staples among the multitude of electrical goods. Besides snap switches, the products covered by the printed standards are as follows:

Rubber-Covered Wires and Cables, Armored Cables and Cords, Cabinets and Cutout Boxes, Knife Switches, Soldering Lugs, Flexible Cords, Renewable Cartridge Enclosed Fuses, Electric Ranges, Flexible Non-metallic Tubing, Rigid Conduit, Cartridge Enclosed Fuses, Electric Signs, Panelboards, Cutout Bases, Ground Clamps, Fixture Wires and Heater Cord.

The standards, supplemented by procedure manuals for individual manufacturers, specify every feature of the examinations and tests on electrical appliances and systems submitted to the Laboratories. Moreover, they describe in some detail the nature and scope of the follow-up inspections at factories, and tests of market samples.

Some of the regular tests have been described. For many new products no regular requirements and tests are specified, and it may be said that there is an unwritten volume of the Laboratories' Code—in the brains of the test engineers!

In addition to the Laboratories' code of standards, there is another widely-known compilation which originally appeared at the back of the printed National Code, where it then took up not more than several pages. It is the official list of products—devices, appliances and systems—which have been found to comply with the requirements of all three codes. In 1906 it was decided by everyone concerned that this information should be separate from the National Code; and, inasmuch as the Laboratories made the investigations and tests and issued the manifests of compliance in the form of labels, it was selected as the logical institution to take charge. This information is now issued only by the Laboratories, in the form of its semi-annual *List of Inspected Electrical Appliances*. The April, 1922, edition has over 250 pages, and its index contains more than 250 headings of classes of devices. Names and addresses of the manufacturers are also given, as well as brief explanatory statements.

Thus from humble beginnings the Laboratories' electrical work has grown to its present great proportions and has developed with the electrical industry a coöperative

relationship of public service that has been summarized by Vice-President Pierce in the following words:

As the Code and as the Underwriters' Laboratories' standards represent the experience of the industry, and have come largely out of the industry itself, so the public respect for them, and the support of them, so far as they are reasonable, and as they are revised to keep pace with the industry, from year to year, must rest—not with the compulsion of the insurance company alone; not with the force of law backed by the policeman, as representing the city inspector; but with the intelligence of the fair-minded, disinterested, and successful electrical industry, confident of its service to the public, proud of its record, and believing in its superiority in rendering a form of service which no group other than the electrical industry can render.

CHAPTER ELEVEN

A Department that Outgrew Its Name

1. Correcting "The Defects of Their Qualities"

THE American mind is naturally inventive, which is one of the chief reasons why it is so hard for protection to catch up with hazard. No sooner does some safety problem approach solution than there may appear on the market a new material or a new device that upsets calculation. Of course, people do not set out to invent hazards. They are working for useful results, and the hazard is incidental, often unrecognized, until it discovers itself. There are mysterious fires, it may be, or unexplained explosions, which, when traced to their causes, are found to have originated in some new form of utility. Then, once more, it becomes necessary to start patiently and painstakingly on the process of obviating such hazards.

It can be stated with certainty that at any given moment thousands of minds at various points are then engaged in invention or research. A closed door, which one passes quite unaware, may hide an inventor or a scientist, absorbed in labors which next month or next year may change the course of some established industry. This is

true particularly in the unceasing search for sources of power that is increasingly one of the world's greatest problems, but it applies as well to almost every other field of human endeavor. This is one of the reasons why the work of Underwriters' Laboratories does not approach completion, but grows ever more diverse and extensive.

There is a large and very useful group of solids, gases, and liquids which, for want of a better term, may be called "hazardous substances," meaning thereby those having the liability to sudden and violent chemical change. These bring service and peril to mankind in many ways. Their principal service is due to the fact that energy liberated through the chemical action can be transformed into power, light or heat; the peril arises from the danger that such liberation may be excessive and uncontrolled. In other words, they "have the defects of their qualities".

Like many other gifts of science, these hazardous substances are comparatively recent associates of mankind. Our great-grandfathers knew gunpowder as practically the sole representatives of the group, and the dictionaries of even one generation ago defined the now indispensable gasolene as "a volatile fluid used for cleaning". Today, however, power-hungry civilization has learned to unlock the immense potentialities for service of which it was so long ignorant but, in so doing, a succession of disasters has warned it of the necessity for developing safeguards through constant, comprehensive scientific research. At

no other place in the world is there so adequate a study of safety methods and appliances for use in connection with hazardous substances as at Underwriters' Laboratories. Much of the nation's recent progress in this direction is traceable to the work of two of the departments—that of Gases and Oils and that of Chemistry.

The title "Department of Gases and Oils" is used merely for convenience because no more descriptive title has yet been found for the wide and diverse activities of the department. It deals in general with hazardous substances but so, also, does the Chemistry Department, the main difference being that the Chemistry Department's work concerns itself with the *inherent properties* of these substances while that of Gases and Oils takes into account the *mechanical means* for producing, storing, handling and utilizing them. Constantly the two departments coöperate; often, unavoidably, they overlap. The Gases and Oils Department dates back almost to the beginning of the work of Underwriters' Laboratories, coming next in order to the Electrical Department. It has already been told that the discovery of acetylene at about the same time as the founding of the institution led to the production of crude and dangerous types of generators and the study of their hazards by W. C. Robinson, Mr. Merrill's earliest associate. The testing of acetylene generators has been an important feature of the work ever since, but with it have been grouped an ever-widening range of activities

in many other fields, including, in particular, that of "first-aid" fire extinguishers, more fully discussed in the chapter on fire-fighting equipment.

2. The Handling of Hazardous Liquids

The most familiar of the "hazardous liquids" are gasolene, kerosene and other members of the petroleum family; to them may be added the alcohols and ethers, collodion, turpentine, carbon disulphide, paints and oils and their constituents; dryers, lacquers, and various other volatile and flammable fluids, some of which are subject to spontaneous ignition. The devices and appliances connected with them are so many that it is manifestly impossible to go into a detailed discussion, but two or three instances will give a glimpse of the nature of the tests conducted.

Foremost, of course, comes gasolene, that miracle of liquid energy which is known wherever there are roads to be traveled or farms to be tilled. With a capacity so great that the vapor from one gallon is equal in explosive power to eighty-five pounds of dynamite, its well-nigh universal storage and widespread use present a serious safety problem.

For example, in a recent instance a tank truck stopped at a service station to refill the underground tank. There was a sudden fire of unknown origin. The operator dropped the hose and ran, but soon there was an explosion which enveloped in flames everyone within a radius of

LEARNING WHAT WOULD HAPPEN IN A FIRE

There are five gallons of gasolene in the glass container of this visible measure discharge device. Would they cause an explosion in case of exposure to an outside fire? Apparently not, for when tested with a hot blaze from the vapor of twenty gallons poured into the pan beneath, the glass merely cracked; there was no explosion

STUDYING GASOLENE SUPPLY DEVICES

The widespread use of visible measure discharge devices indicates the importance of safeguarding them in every respect against gasolene leakage or other defects. At Underwriters' Laboratories they are carefully checked for suitability of materials, arrangement and strength of parts and workmanship, and are subjected to various tests dealing with reliability of operation, leakage in joints, rate of flow of liquid, the liability to accidental breakage and all other essential points

fifty feet. Eight persons died and people two hundred feet away were painfully burned.

The Department of Gases and Oils has spent much time on the obviating of such disasters and has investigated many devices, some of which have presented difficult problems, as in the case of a new type of curb pump in which "during the process of development the manufacturer consulted with the Laboratories continuously."

The extent of the work thus devolving upon the Laboratories may be gauged from a glance at the mere headings of the description of the device as given in the Laboratories' 5,000-word report:

> Assembly, base, motor, pump, platform, rotary pump, filter, hand drive mechanism, measuring compartment, glass cylinder, dome, cylinder guard, valves, operation, locking and interlocking mechanism, pipes and fittings, packing materials, protection of metal parts, hose vent, housing, meter, hose and attachments and electrical equipment.

From the fire-prevention viewpoint the essential features of the investigation included studies and tests with regard to construction, probability of leakage, strength, deterioration and suitability for use. The usual tests were made as to construction, strength, electrical features, and operation tests, also some special leakage tests. One test consisted in trying to build a pressure in the measuring compartment by various means, and it was noticed that this could not be done—on the contrary, a partial vacuum was developed. The leakage tests consisted in applying

pressures of twenty-five or of fifty pounds per square inch, according to the nature and use of the parts, and then watching for leaks. Studies and tests were also made of the locking and interlocking mechanisms and safety features.

An interesting investigation involved a self-service coin-operated curb pump to which the motorist is to be attracted by a sign that reads: "Help Yourself Gas." On investigation he finds three coin slots, for quarters, halves and dollars, three gauge-glasses with pointers showing how much he will get for each coin, as per current rates; also these directions: "Notice. 1. Place hose in tank. 2. Drop only one coin in slot. 3. Press button. Gas will be measured, then flow into tank." This device involved an entirely new hazard, for the question was asked: What if it got out of order and failed to supply "gas" after accepting a coin? Might not an irate motorist thereupon pick up a rock and vent his spite on the machine, causing leaks and perhaps a fire? Nothing like this problem had ever come within the sphere of the Laboratories, but appropriate tests were devised, and it was ascertained that the machine was reasonably safeguarded by a mechanical provision for closing the slots whenever there was no gasolene in the supply tank or no compressed air in the system that forced the gasolene up to the measuring compartment. During the investigations—which covered many other items—improvements were made "in practically every detail of construction"

and the final form of the device was very different from that originally presented.

The use of gasolene in dry-cleaning establishments has led to the development of various automatic and auxiliary extinguishers to reduce its fire hazard. An impressive demonstration of some of these safeguards was made at an Atlantic City cleaning establishment during the May, 1922, convention of the National Fire Protection Association. The gasolene was repeatedly ignited and each time was swiftly extinguished by means of automatic lids, steam jets or foam.

The tremendous utility of kerosene oil, because of its wide distribution, ease of handling, comparative cheapness, and the fact that it is not volatile at air temperature, have led to its employment in millions of households, as well as its use for industry and in transportation. Mechanisms without number have been devised in connection with various phases of its use, and many of these have been tested and listed by the Laboratories. Among them may be mentioned the comparatively recent development of kerosene oil burners for household furnaces.

These tests involved a great responsibility because of the fact that outside underground storage tanks are not always practicable in dealing with homes, and the additional facts that the devices always must be "ready to run" and not unduly expensive, without sacrificing any of the precautions for safety. In fact, the function of the

Laboratories as regards oil-burning mechanisms is somewhat different from its policies on most other subjects. It not only strives to eliminate hazards but to make sure that these burners justify the manufacturers' claims as to simplicity and positiveness of operation; this is because burners that tempt the user to tamper with them are almost certain to get out of order and become hazardous.

Briefly summarized, here are some of the direct effects of the Laboratories' activities upon the manufacture of domestic oil burners, whether listed or not:

Pipe lines are being better protected from damage.

Oil line joints have been made tighter—metal-to-metal unions of standard type are beginning to be preferred to the gasketed types; litharge, glycerine and shellac are being used increasingly; the use of rubber, which disintegrates rapidly in contact with oil, and the custom of filling the auxiliary storage tank in the basement, are being discouraged.

Valves are being made of better and safer construction. This is particularly the case with regard to automatic shut-off valves which may sometimes play an important part in safeguarding life and property. For example, during the war a hot billet of steel was dropped upon a feed pipe containing oil under a pressure of 100 pounds per square inch or more. The pipe was broken and the oil ignited, but the automatic shut-off valve immediately operated and the flow ceased at once. As a consequence

SAFETY REQUIREMENTS IN OIL-BURNING EQUIPMENT

Many motor-driven oil burners are now on the market. Their use has become an important consideration in judging of fire hazard. The Laboratories makes frequent tests of such devices. In so far as practicable, they must be noiseless, odorless, uniform and reliable, free from carbonization or other troubles that would lead to tampering, and supplied with all necessary safety features. The tests consider supply lines, strainers, valves, automatic cut-off, pre-heating pan, electrical system, generator, air duct and many other items

FORTY DEGREES BELOW ZERO IN CHICAGO

This picture does not suggest a winter temperature, yet the engineers here depicted are making carbon dioxide *snow* by the rapid expansion of liquefied carbon dioxide, which is being released from the cylinder and retained in the bag. Why? In order to learn whether extinguisher fluids will freeze under severe conditions of cold

there was nothing more than a momentary flash of fire instead of an outburst of flame that might otherwise have filled the building. As this accident took place in a munitions factory the catastrophe which might have resulted might well have been of national importance.

Since the average fuel oil bought for domestic use contains sediment, manufacturers have been encouraged to provide strainers of acceptable types, and so to install them that cleaning may be accomplished without dismantling the pipe line.

It having frequently happened that manufacturers neglected to consider the rigidity of the burner itself as installed, the Laboratories has brought about the provision of secure attachment means, so that external shocks are now of little consequence.

Burners with moving parts are now being sold with drain pans to catch waste lubricant, thus avoiding the former unsightly and hazardous accumulation on basement floors.

The importance of such work was shown by an analysis of ninety-five fires resulting from fuel-oil systems published in the National Fire Protection Quarterly; among these were the following direct causes:

Broken and defective pipes, fittings and valves	38 Fires
Explosions in furnaces or in pipes	6 "
Broken and defective burners and burner connections	5 "

Oil getting into air pipes	3	Fires
Defective or improperly installed tanks . .	3	"

It is safe to say that in these particular cases the proper installation of improved supplies would have avoided fire. Seven more cases were from overheated oil furnaces and may be ranked as partly preventable by mechanical means while most of the others were chargeable to human carelessness.

3. Dealing with Hazardous Gases

Such fluids as gasolene owe their value as power to the fact that they may be easily converted into gas, but there are also many products that are naturally gaseous at air temperature, and must be handled and used in this form. Among these is acetylene, which, next to electricity, is the oldest concern of the Laboratories. Everyone is familiar with the brilliant white flame produced by acetylene, that strange-smelling gas that results from the action of water upon gray rocklike calcium carbide. Its illuminating power and its great convenience have given it a widespread household use, particularly in country districts. It has been much employed for automobile lights and within the past few years the oxy-acetylene torch has shown its value for use in welding and its power to cut through steel as a saw cuts through a board.

Repeatedly this power has been used in saving life.

At the time of the "Eastland" disaster, when a crowded excursion steamer turned over at her pier in the Chicago River, most of the survivors owed their lives to the fact that the rescuers were able to cut their way through the metal plates of the vessel's hull.

All this has come about within a single generation and as in many other instances, utility and hazard have developed side by side. For nearly thirty years a succession of acetylene generators and appliances have been submitted in completed form, in model form, or even as inventors' drawings to the Gases and Oils Department of Underwriters' Laboratories and have been developed in consultation with its acetylene experts. Indeed it was in connection with the work in this field that the well-known "plan of investigation" was first worked out. The acetylene industry has benefited by all this work and manufacturers often express their appreciation, even in cases where the engineers have insisted on costly changes in design, construction or process.

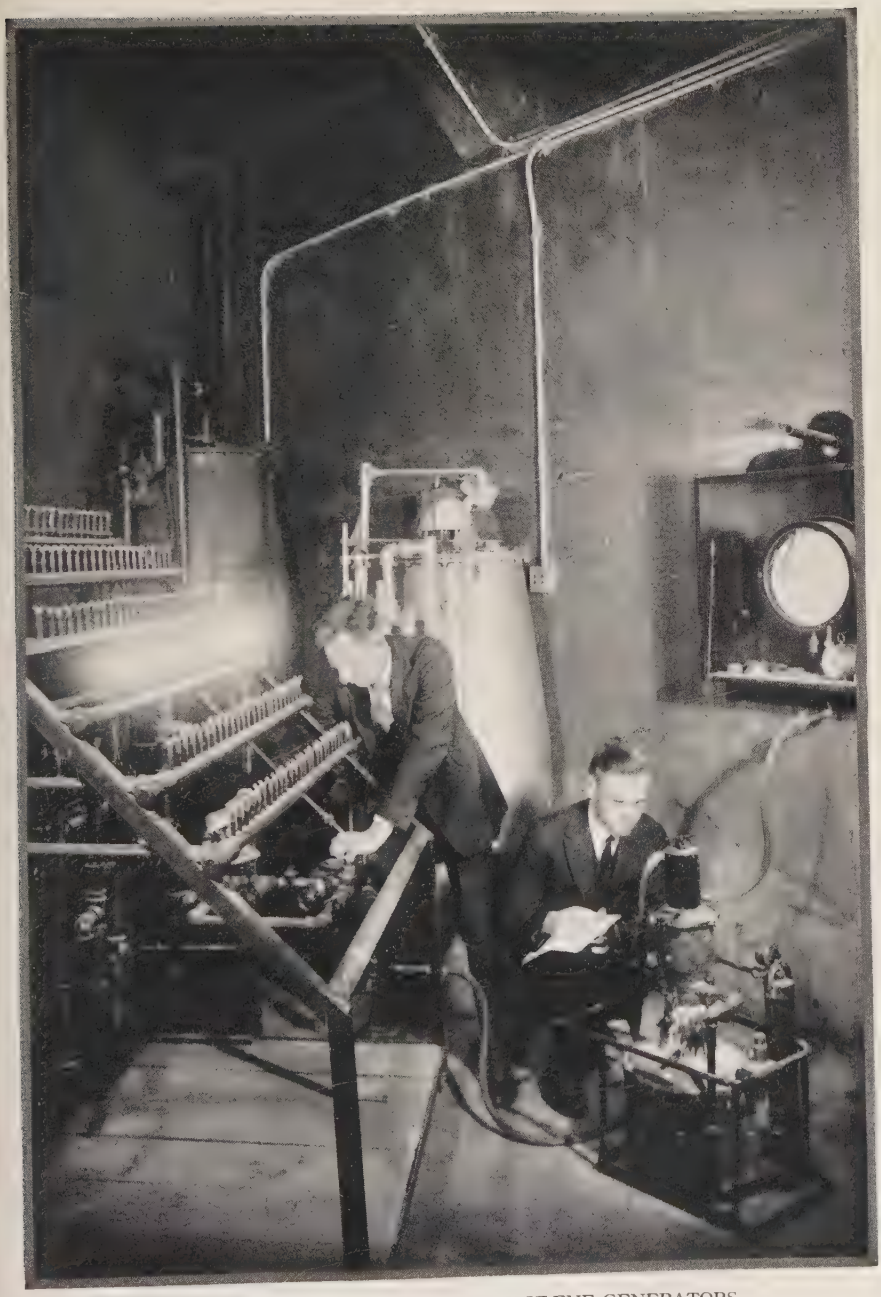
For example, in the recent case of a "Class A" generator for welding and cutting, ten improvements were made between the time of first submission and the final Council Report, and these changes included the complete redesigning of certain important parts, improvements in the internal protection against corrosion and the addition of various safety features that were not in the original design.

Some of the tests for these devices are based on reasons

that would not be apparent to the layman. An example of this is found in the tests of the composition of the metal parts, in which brass with a high copper content is not allowed, because it might be subject to chemical action that would result in the formation of copper acetylide, and copper acetylide is a detonating explosive. Such points as this emphasize the need for wariness and technical understanding in conducting investigations in order that the unconscious public may be shielded from the multiplication of dangers. The degree to which the hazards of acetylene have been reduced is the result of exactly this kind of painstaking attention to details, and the Laboratories' listing of a device stands for searching tests that are calculated to uncover its every defect.

While acetylene generators were the earliest point in the work of this department, other forms of gas generators and appliances had long given concern to the fire insurance companies, as was evidenced in a report by a "Committee on Gas Machines" of the National Board of Fire Underwriters made in the late 60's. At the present time, both illuminating gas and natural gas, as well as some other forms, are employed in millions of homes as well as in many commercial and industrial establishments, and the Department of Gases and Oils is called upon to deal with many devices having reference to them, as they are the cause of numerous fires and explosions.

Here is a characteristic instance: One night in a printing



STUDYING THE SAFETY OF ACETYLENE GENERATORS

Full-load operation test of a medium-pressure small generator, using low-pressure burners supplied through a reducing valve, the amount of acetylene being measured by a gas meter and the pressure variations being recorded by the gauge shown hanging on the wall. Two large generators stand in the background, awaiting their turn to undergo the many tests which have contributed to the improvement of these devices since the first crude and hazardous forms were submitted thirty years ago

OPERATING TESTS ON ACETYLENE RELIEF VALVES

Acetylene generators of the medium-pressure type are not to be subjected to pressures in excess of fifteen pounds per square inch. This necessitates the provision of adequate mechanical relieving facilities in the form of relief valves. Relief valves are subjected to tests to determine the reliability of operation, sensitiveness, relieving and closing pressures and volume relief

plant the gas pressure fell very low, causing the automatic regulator to open wide. After midnight the pressure returned, but the regulator failed to operate. As a consequence the boiler and flue became so overheated as to ignite the ceiling over the boiler and an $18,000 fire resulted. It is presumable that if the gas regulator had been a product listed by the Laboratories, this would not have occurred, since exactly such points come within the range of the test.

Where natural or city gas is not available and gas is desired, it can be made in any of the several types of listed gas producers. Considerable attention is also given to labeled gas systems based on the use of liquefied hydrocarbon gas made from petroleum distillate, which is conveyed from the familiar steel shipping cylinders. Gasolene gas machines also come within its scope.

4. Miscellaneous Devices

Under this heading the work of the department of Gases and Oils ranges at some points far afield and includes such items as incubators and brooders, heating systems, lighting plants, furnaces, clothes driers, dry-cleaners' equipment, equipment for various hazardous industrial processes, baling presses, doughnut machines, pitching plants and many other devices which must be safeguarded to the users.

Among these a recent report of unusual importance con-

cerns a heating device that is coming into widespread use, namely, the "pipeless" furnace. The use of this single register furnace is practicable only in houses that have large and permanent openings between floors and between rooms, a form of construction which is not encouraged by insurance men because it permits the easy spread of flames. However, such houses are very numerous, they are not likely soon to be legislated out of existence, and they can be heated economically by pipeless furnaces. Therefore, the problem of the Laboratories was practical, not academic; it was that of making sure that these heating devices were rendered as free as possible from hazardous features. The tests included the following features:

Design and Construction (form and arrangement of parts, suitability of materials, workmanship).

Practicability (of packing and shipping, of installation, of operation and of maintenance).

Durability (wear and tear, rough usage, corrosion).

Strength (of parts and of the furnace).

Uniformity (of parts and of the furnace as manufactured); and also this particular item:

Fire Hazard (radiation of heat, conduction of heat, combustible sweepings and rubbish, combustible materials over registers and failure of fire pot).

The fire hazard tests were conducted under conditions representing a dwelling house, in which the basement and first floor were arranged as in most installations. A num-

ber of thermometers were placed at various points and readings were taken at intervals. The temperature directly over the center of the hot-air outlet was found to be a little over 300 deg. F. This prompted the question as to what would happen to combustible materials if these were to obstruct the register? Therefore a severe test was arranged by covering the register with heavy burlap representing a carpet or rug. By means of a specially hot fire with a wide-open damper, the burlap was ignited in the middle in forty minutes, but its burning developed a strong odor that was taken into consideration as one of the safety factors of the test, it being assumed that it would furnish warning of danger to the people in the house. Such conditions, of course, represented an abuse of the furnace that could not occur with reasonable precaution, therefore this ignition did not result in the withholding of a classification label.

Further tests included the placing of light cloths on the register, the throwing of sawdust and particles of paper and rags into the cold air inlet and the warm air outlet (to represent a lazy maid's disposal of sweepings), the placing of excelsior and rags in contact with the furnace, and the covering of the entire register with sheet iron. None of these developed results of special hazard and the furnace was finally listed by the Laboratories, but with official notice that the installation must be made by the manufacturers' trained agents and must be approved

by inspection departments having jurisdiction in the locality.

Such tests have little relation to the original purpose of the department—that of dealing with hazardous substances—but are a natural outgrowth of its work with mechanisms and are another illustration of the way in which questions of safeguarding from hazards, in the widest variety, drift inevitably to the one institution that is definitely associated with study of this kind.

CHAPTER TWELVE

The Study of Chemical Problems

1. The Department of Chemistry

THE World War forced the subject of Chemistry on the attention of millions of people to whom that word previously had been merely a learned-sounding term. Of course all previous use of explosives had been based upon chemical laws, but when despatches from the seat of war began to carry references to "chlorine," "phosgene," "mustard," "tear gas" and the like, the public mind commenced to perceive the existence of a realm of unfamiliar phenomena that were likely to have an important influence on the political destiny of the world. Today, it is the general opinion of authorities that future wars, if such must be, will partake largely of a chemical nature, and many seriously question whether civilization would be able to survive the immense destruction of life and property which would result.

Fortunately, chemical knowledge has application to the arts of peace in ways that are even more diverse and extensive. In industry and in agriculture, for example, it is being applied in a manner that is almost revolutionary. Newer developments along synthetic lines suggest possi-

bilities of future achievements that are staggering in their scope. Even the accomplishments of the past few years have added extraordinarily to the resources of humanity. Thus chemistry, instead of being an academic study, is more and more coming to be discussed in terms of industry, economics and human safety.

For such reasons there is nothing merely speculative about the Chemistry Department on East Ohio Street. It is one of the most intensely practical branches of the whole institution. In general, its work may be sub-divided under four heads: first, tests of materials used in the construction of certain products offered for labels; second, investigations as to the properties of various "hazardous substances"; third, certain lines of general research for the purpose of gathering fundamental data without which the business of insurance is more or less a matter of gambling; and, fourth, a few mechanical processes not strictly to be defined as chemical, but relating to products with which the Chemistry Department is concerned.

This department is in fact in constant coöperation with the others, and, as is inevitable, there are certain overlapping points. For example, the Electrical Department can run tests on steel-clad copper conductors as to conductivity, but when these conductors are buried in the ground corrosion is a factor that must be taken into consideration. Corrosion, being a chemical process, can be dealt with only by the Department of Chemistry.

2. *Tests of Hose and Wire*

It may seem strange to say that two of the largest concerns of the Department of Chemistry are fire hose and insulated wire, but it illustrates the fact that chemical tests enter vitally into many subjects that at first do not appear to be chemical.

The need for testing fire hose was the original reason for the organization of the department, for, as was shown in the chapter on fire-fighting equipment, the deterioration of hose is an ever-present danger. Standard fire hose is lined with rubber but the grades of rubber and of substances masquerading as rubber are many and their differences are not always apparent to the eye. In order to judge of durability, it is necessary to ask such questions as: What is the percentage of its acetone extract? of its chloroform extract? of its alcoholic potash extract? and of its ash and sulphur content? Such questions can be answered by chemistry and therefore a department of chemistry was seen to be essential. Once established, its usefulness was so great, that it quickly grew into a wide range of operation. All work on fire hose is done by this department, which conducts even the physical and hydraulic tests. It goes into a study of the cotton jacket of rubber-lined hose and the linen fabric of unlined hose. It tests the yarns and the weave, it determines "air dry" and "bone dry" weights and does

various other necessary things that are too technical for discussion in these pages. It even puts the fibers of which the yarns are made under the microscope and learns important facts invisible to the unaided eye. Incidentally, it may be said that the American Society for Testing Materials has adopted Underwriters' Laboratories' standards for fire hose.

In the chapter on electricity something has already been said on the subject of rubber-covered wire and this, while it constitutes one of the important activities of the Chemistry Department, need not here come in for discussion, except to say that the tests have reached a point of efficiency where this product is now labeled at the extremely low figure of *seven-tenths of a cent for each hundred-foot length.* This is a striking example of the Laboratories' claim that the cost of labeling products need not add to their selling price.

Closely related to this subject of wire is that of conduits, which also comes in for considerable attention by the Department. Steel conduit is by far the most popular, three hundred million feet of it being labeled in one year. It must, of course, be rust-proofed, and whether this is achieved by enameling or coating with zinc, it involves chemistry. For instance, there are many ways of applying the zinc—sherardizing, hot-dipping, electro-plating with or without copper sub-coat, etc. The Chemistry Department is constantly running check tests on samples

GENERAL ANALYTICAL LABORATORY

Both of these chemists are investigating rubber compounds used in fire hose and rubber-covered wire insulation. The one in the foreground is engaged in filtration and is pouring a solution from a beaker into one of a row of filters in the rack, while the chemist in the background is placing rubber samples in an electric oven in order to make a determination of their ash content

PREPARING RUBBER SPECIMENS FOR TESTS

The assistant in the foreground has a small rubber sample taken from the lining of a fire hose and is removing the cement backing in a buffing machine, after which it will be tested for its tensile strength. The assistant in the background is feeding another sample of rubber, also taken from the lining of the fire hose, into a grinding mill. The ground rubber is to be given chemical tests. The mill is equipped with a safety device and will stop automatically in case the operator is in danger of having his hand drawn between the rolls

from the numerous factories, as this work involves delicate determinations which cannot be left to the factory inspectors and the ordinary factory testing apparatus. Moreover, it was the Chemistry Department which had to devise the tests and draw up the procedures. An interesting instance of its work with regard to conduit was the settlement once for all of the "least amount of zinc" question which had for years kept tongues and pens busy among trade bodies, government bureaus, engineering and scientific societies, insurance circles, etc. Another was the equally final ending of great discussions as to whether or not it was advisable to give the conduit a copper subcoat before plating the zinc by electrolysis.

3. *Miscellaneous Activities*

The omnipresent match has been called "the most valuable and the most dangerous article made by man; it is the starting point of nearly all intentional fires and of most unintended ones as well. Since, as has been said, "every box of matches carries *fifty potential conflagrations* within its walls," and since five hundred thousand matches are struck every minute on the average, in the United States alone, it is important to see that they are surrounded by safeguards. Consequently, the testing of matches was taken up by the Chemistry Department and standards were established for "strike-on-box" and "strike-any-

where" matches which are designated as "Class A" and "Class B," respectively.

It is interesting to see miniature pile-drivers, only a few inches high, drop their tiny weights on match heads in determining the force of a blow required to ignite them, and to watch the operation of little machines for testing the strength of the wooden splints, or of thermometric apparatus for determining the heat ignition points of the chemicals. There are other steps as well, for the testing of even the lowly match is a complicated process.

"Strike-on-box" matches are required to have heads made of a chemical compound which is stable, whose heat ignition point is above 340 deg. F. with low susceptibility to ignition by shock, and with the explosive character and the "fly hazard" during combustion reduced "so far as is at present practicable for this type of match." The sticks must be of specified dimensions, strength, uniformity, and must be treated chemically to prevent "afterglow".

"Strike anywhere" matches call for even greater precautions and must be especially well safeguarded against ignition by shock. The public is already acquainted with the large-lettered words "Inert Bulb, Protected Tip" on safe strike-anywhere matches; it is the result of the Chemical Department's work.

Before leaving the subject of matches it may be interesting to note that Laboratories' inspectors at the factories

producing labeled matches fill out report blanks having spaces for *over two hundred answers* to the "mere routine" questions. No wonder that all matches used in America, whether labeled or unlabeled, are becoming safer.

Another concern of the Department of Chemistry is the subject of composition roofings. Backed by vigorous advertising and selling campaigns and aided by the requirements of the building codes in many communities, thousands of acres of such roofings are sold every year in the United States. They are generally claimed to be "safe from danger from sparks or flying brands," and it is important that the public find out to what extent such statements are true. Therefore, the Laboratories conducts the fire tests already referred to under building materials, but this alone is not sufficient, for the combinations of materials must pass through the tests of the Department of Chemistry. These tests throw light upon the question of durability and fire hazard.

Then there are the invisible products—the commercial gases—which now are being marketed in thousands of metal cylinders and find an increasing use in industry. These gases involve hazards which the Chemistry Department is called upon to study. For example, oxygen and hydrogen commonly are produced by sending a current of electricity through water, whereupon the water molecule is broken up and the component gases are freed.

They are, however, ready to unite again with violence,

under certain conditions which must be guarded against. For this reason it is important that they be kept separate, but the process of electrolysis makes it difficult to secure either gas free from some slight percentage of the other. If this percentage be small enough it involves no particular danger, but if the proportion of mixture be somewhat increased there is a possibility of explosion.

In this field, the Laboratories has been of great service to manufacturers by determining the explosive ranges and laying down standards which cover not only the purity of the products but safety features in the processes of production. This was done *at the request of the manufacturers themselves*, after some unfortunate accidents at their plants. Close coöperation with the industry is maintained through its official body, the Gas Products Association. With regard to safety features, engineers from the Laboratories' Casualty Department have cooperated with the chemists. The Inspection Service for these plants began in 1919, and is now applied in plants situated in no less than eighteen states. Human safety, therefore, at many points depends upon exact knowledge as to such proportions and other conditions of hazard.

One of these other conditions has to do with pressure. It is well known that gases which may be comparatively inert at air pressure become difficult to deal with when compressed sufficiently for storage in cylinders. What, then, is the range of safety under compression?

WHEN WILL A MATCH TAKE FIRE THROUGH HEAT ALONE?

The answer to this question will make it possible to guard against thousands of unnecessary fires. In this apparatus, the matches are placed in a specially designed holder in contact with the bulb of a thermometer, and enclosed in a test tube. This tube in turn is immersed in an oil bath heated by a gas burner. As the temperature rises, the matches finally burst into flame, and the ignition point as shown by the thermometer is carefully recorded

ANALYZING GASES

If commercial oxygen contains more than a small percentage of hydrogen admixture, its handling and use are dangerous. With the Haldane apparatus here shown a chemist is seen making a determination of the proportion of these gases present in the sample. The picture also shows a Moorehead apparatus for determining such constituents as carbon dioxide, illuminants, oxygen, carbon monoxide, hydrogen and methane in furnace, fuel and illuminating gases. This scene shows a corner of the room devoted to gas analysis and containing other interesting apparatus

One important series of tests conducted by the Department of Chemistry in order to answer this and other questions is thought to be the most elaborate ever made. It required hundreds of pieces of specially designed apparatus and dealt with mixtures of hydrogen and air, ethyl and methyl chloride and air, ordinary gasolene and air, "casinghead," or so-called "wild" gasolene and air, natural gas and air, and similar gases.

Because of the immense pressures developed in the various experiments—pressures sufficient to hurl a locomotive through the air—special appliances had to be designed. One, a nickel steel bomb built out of navy armor plate at the Bethlehem steel works, weighs so much, although the gas chamber is only 4 x 8 inches, that it was necessary to install a special hoist to handle the cover alone.

The problem of photographing explosion flashes traveling at a speed of 20,000 feet a second required the development of special photographic films, as no existing film was sensitive enough to record light traveling at such tremendous speed.

The explosion chamber for the photographic tests is a steel tube four inches in inside diameter and ten feet long, surrounded by very thick hardened steel walls. At either end, a narrow slit, two inches long, is covered with a thick quartzite lens, communicating with a periscope attachment, which, in turn, conveys the light to specially built cameras.

The backs of the cameras, placed opposite each other, are formed by a motor-driven cylinder, two feet in diameter, driven at a speed of 1,700 revolutions a minute. Around the cylinder is wound the photographic film, which passes before the cameras at a speed of approximately two miles a minute.

In action, the explosion flash, as it becomes visible at the nearest edge of the slit in the steel cylinder, is reflected on one edge of the film. As it travels across the slit it prints a corresponding line across the film, at an angle, due to the speed at which the film revolves. A corresponding photograph is made when the flash passes the slit in the other end of the tube ten feet away.

By measuring the angles of the two photographs and knowing the speed of the film, it becomes possible to calculate the speed of the flash. The result shows how rapidly and how far fire caused by an explosion of the gas under test will spread in a factory building.

In the manufacture of safes, the space between the outer and inner shells is filled with some sort of composition to resist heat. This insulation may remain hidden away for a generation or more, until some day a severe fire determines whether or not it is faithful to its trust.

The Laboratories' fire tests of safes described in the next chapter show the heat resistance of this insulating material when it is new, but the Department of Chemistry, by thorough studies of the composition, is able to judge as to

the permanence of its value. Chemical tests also indicate whether explosive gases are likely to be developed within the safe from great heat. There have been many cases in which safe doors have been blown open during a fire from this cause, with, of course, the ruin of contents.

Spontaneous combustion, or, more properly, *spontaneous ignition*, is the real cause of so many mysterious fires, that precautions are of great importance. Even the fire loss that is definitely traced to this cause averages more than $1,000,000 a month in the United States.

Consequently, the Department of Chemistry is constantly called upon to deal with the liability of various materials and compounds to burst into flame under certain conditions. Sometimes this study has unexpected results. Few things could seem more free from fire menace than the thin red skins that cover the meats of peanuts, and yet, in all seriousness, Underwriters' Laboratories made a scientific investigation to learn whether these peanut skins held danger of spontaneous ignition. Moreover, it found that they *did*. To the layman this might sound like testing run mad, yet it was intensely practical, as is all the work done by the institution.

It happens that peanut meats are extensively used by candy manufacturers and that the preparation of these meats has become an industrial process. This includes freeing them from the skins, which thus accumulate in considerable quantities.

A fire in Virginia was believed to have arisen from the spontaneous ignition of these skins and a bag of them was sent to the Laboratories for investigation. Here it was quickly determined that the fragments of meat adhering to many skins contained a considerable percentage of oil; this, in view of the fact that the curling skins packed loosely (thus being surrounded by oxygen) constituted a recognizable fire hazard.

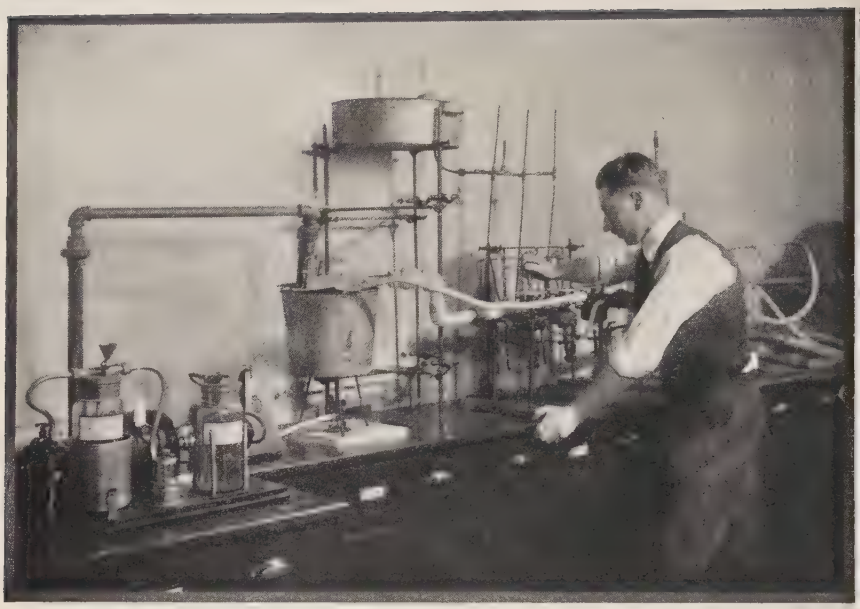
Other items of interest among many include investigations of foam fire-extinguishing compounds, of processes of coating metal to prevent corrosion, of processes for flame-proofing excelsior, of flame arrestors for safeguarding motors used in ether anesthetic apparatus, of the explosibility of wood flour, of the heat expansion of gasolene, and of the hazards of portable fuel for industrial and domestic use.

An example of the last-named concerned the new and growing industry of producing "solidified alcohol" or "canned heat".

Of the various makes, one was submitted by its manufacturers with the claim that it was less hazardous than others because it maintained its solid form while burning or when subjected to the temperature of hot climates. The most obvious test was to light a can and overturn it on a wooden floor in order to see what would happen. But Laboratories' approval is never given so easily, and the product was put through various chemical and practical tests.

LEARNING ABOUT THE "FLASH POINT"

What are the exact temperatures at which certain oils and asphaltic compounds used in roofing will flash into flame? This is being determined in the test here pictured. On the bench, from left to right, are a Pensky-Martens closed cup tester, a Tycos Standard U. S. Bureau of Mines flash point tester and a Tagliabue closed cup tester



PREPARING AN EXPLOSIVE VAPO-AIR MIXTURE

One of the important studies of the Department of Chemistry has had to do with the propagation of flame in pipes. Disasters have been caused by the swift passage of flame through the connections between tanks of explosive gases. In order to devise effective flame arresters, it has been necessary to study the conditions existing in such pipes. This picture shows a chemist adjusting a carburetor on an apparatus for obtaining explosive mixtures of air and various vapors

MAKING MICRO-PHOTOGRAPHS

One of the important means for determining the character of metal used in certain tested products is that of polishing and etching the surface of a specimen and then making a greatly enlarged photograph of its micro-structure by means of the apparatus here shown. Small differences, invisible to the naked eye, may have an important bearing on the behavior of the metal under conditions of use

For example, would it become volatile on a very hot day in the tropics? This was answered by evaporating it to dryness at 65 deg. C. (149 deg. F.) in an electric oven and then using the iodoform reaction to determine the volatile ingredient.

Another analysis identified the non-volatile ingredient, and then some of the fuel was burned in a crucible to learn of its ash content. The chemists now knew all about the substance and could give it a fire rating, but this was not enough, because it is sold in cans, and must be considered in that form. Therefore burning cans were upset to see whether there would be any spilling of flaming liquid, the fire was blown upon by strong air currents to note the result, the heat radiation was studied to see whether it would endanger combustible material that might stand near by, and many other tests of a more technical nature were made before the exacting chemists finally decided in favor of listing the product.

4. Special Investigations

More than most of the other departments, the Department of Chemistry is occasionally called upon to undertake lines of special research of a purely scientific nature. An example of this kind was that dealing with "the propagation of flame in pipes and the effectiveness of arrestors." Here, certainly, is technical language that suggests little to the lay reader, and yet the lengthy report

that is covered was the result of some really dangerous experiments and had a direct bearing on human safety.

It had become important to learn just what happens when mixures of air and various vapors explode in tanks and pipes and just how the explosion flames can be intercepted without stoppage of the pipes. This investigation was begun during the World War at the instance of the du Pont Company and the report was made in October, 1919. It dealt with some factors that were mysterious subjects, even to scientists, and required a formidable equipment of apparatus, such as bombs and other pressure-proof containers, air tank apparatus, mixing apparatus, freezing apparatus, sampling devices, ignition systems, composition apparatus, chronographs, manographs, indicators, gas analysis apparatus and many others. Some of these devices it was necessary to design especially for the experiment. The investigation resulted in a mass of clearly presented information of great value to many industries. The effectiveness of various types of flame arrestors was reported upon for the first time.

Another important investigation has had to do with the so-called "Table of Constants" bearing on thirty-eight oils, ethers, alcohols and other such liquids having hazardous properties. The work of insurance men and even of government regulators must involve more or less guesswork at various points without such information. This

table has not yet been completed but even at its present stage has proved of great value.

There is no room here for even a list of the numerous other special investigations which have been made by the Chemistry Department. All of them resulted in the accumulation of valuable information—sometimes valuable to a single industry, as in the case of the spontaneous ignition hazard of sisal, that Mexican plant whose fibers are used in manufacturing cordage and bagging; sometimes to agriculture, as in the case of hazardous compounds for killing weevil in grain, and sometimes to the general public, as in the case of extinguisher liquids.

Extinguisher liquids of the carbon tetrachloride class have many advantages, not the least of which is that they do not conduct electricity. It had long been noticed that when applied to fire they formed certain gases, and the Laboratories' chemists conducted thorough investigations to determine the nature of the fumes, their corrosive action on metals, the toxic compounds so formed, etc. It was ascertained that while poisonous gases were generated, their volume was so small as to render the extinguishers safe for use except in small confined spaces such as closets. As a matter of fact, everyone who has studied chemistry has breathed some of these gases, and been none the worse; but the war had made the public fearful on the subject, and it was at the instance of the National Board of Fire Underwriters and the National

Fire Protection Association that the Laboratories conducted the experiments and made the thorough report.

From the foregoing it may be seen that the work of the Chemical Department at 207 East Ohio Street is strikingly unlike that of chemical laboratories established elsewhere. Indeed, it is much more than a chemical laboratory, for statics and dynamics, metallurgy and metallography, thermodynamics and pneumatics, hygroscopy, electrical engineering and various other branches of science, as well as organic and mineral chemistry, are drawn upon; a visitor may even find one of the engineers engaged in work that verges upon the field of botany as, for instance, in the identification of the linen fibers in fire hose. While, therefore, it is rigid in its standardization of procedure, the attainment by clients of the objects laid down does not depend on chemical conformity but on performance.

Finally, it affects a greater number and variety of industries than any other single laboratory, and the effect of its activities is fully recognized throughout large fields of production.

CHAPTER THIRTEEN

How Safes Are Made Safe

1. *An Emergency Article*

A LITTLE more than a decade ago manufacturers of safes began to submit their products to the Laboratories for official labeling.

Safes presented a problem very different from those discussed in the preceding sections because their use involved no natural or inherent hazard, and they were not associated either with fire prevention or with fire fighting. On the contrary, the very purchase of a safe implied a recognition of the fact that fire might occur in the premises where it was to be installed, and the safe's principal duty was that of protecting its contents from destruction, no matter how severe this fire might prove to be.

The day has been when safes were considered chiefly in the light of burglar resistance. This function is not negligible even yet, and all safes must furnish some degree of protection against marauders, but modern business methods have more and more tended to the use of boxes in safe deposit vaults for convertible securities, leaving to the office safe the task of protecting business documents

and records that are needed for immediate access. These things do not tempt the burglar; their particular peril comes from the fact that they are made of paper.

When fire destroys such material it sometimes cripples a business more seriously than by the destruction of its stock in trade. Consequently the old-fashioned type of massive safe with its ponderous doors, its heavy bolts, its cash drawer and its ledger compartments, while still enjoying a field of service, has been followed by various sizes and types of containers, housing card and "loose-leaf" records of many kinds and designed for the particular purpose of keeping their interior temperature always below the scorching point. Such containers are now to be found by the tens of thousands in business places throughout the country.

Business men have been educated by many sad experiences to the realization that it is a serious mistake to neglect precautions in the purchase of their safes. A fire is a swift transformer of conditions. Premises that in the morning have seemed free from all suggestion of hazard may by afternoon develop into a raging furnace wherein the safe, with its vital contents, is subjected to a heat of a thousand degrees—of fifteen hundred degrees—even occasionally of considerably more. By evening, walls may fall and floors give way, so that the glowing metal box crashes down from a height of several stories and is perhaps buried under tons of débris.

Under such circumstances physical property of large value may be annihilated, a fact that need not be fatal to the business if its owner be sufficiently insured, but the possibility of resuming operation may largely depend upon the answer to one question: *Are the contents of that buried safe undamaged?* It is with anxious heart that many a business man has awaited the cooling of the ruins to a point where his safe could be dug out and opened—often a matter of days.

The opening of the door has told an immediate story of the temperature that penetrated to the safe's interior while its outer walls were bathed in terrific heat. Sometimes the contents have been found reduced to charred and useless fragments; sometimes they appear to have suffered no damage. This latter is now being met with in an increasing number of cases, a fact that is due in no small degree to the Laboratories' classification tests.

The testing of safes is one of the most searching procedures that take place within the two brown brick walls on East Ohio Street and it is one of the most important. Two new safes standing side by side on an office floor tell little to the layman. Both may have trim lines, roomy interiors, convenient compartments, and neatly painted surfaces; both may render equal service during years of usual routine. Then, one day, there comes the great emergency for which supposedly both safes were created and one triumphs, the other fails.

The possibility of severe fire must always be thought of as existing in the background during every moment of the safe's manufacture, sale, purchase and use. A safe is essentially an emergency article; its real value stands or falls on the single question of its ability to meet extraordinary conditions. This ability must be known at the time of purchase. It can be determined in but one way, viz.: by subjecting the safe *in advance* to the emergency for which it is created. A fire-safe container must have its safety proved by fire. This, however, is not so simple as it may sound.

2. *Preliminary Inspection and the Explosion Test*

The technical reader will find the Laboratories' Standard for testing safes in Appendix XIII, but what is here purposed is merely a brief impression of the actual process.

In the case of all safe manufacturers, various conferences and discussions intervene between the time when the drawings and factory specifications are submitted to Underwriters' Laboratories and the first actual fire test is made in Chicago.

In each instance the Laboratories' engineers study the blueprints and descriptions, inspect the factory with regard to methods of production and even look ahead into the packing, shipping, handling, installation and operation of the safes *before a single one is built for formal*

submission. Advice and suggestions are given in the light of the manufacturer's statement of claims and the Laboratories' standard. Following this test, sample safes are built at the factories, under the personal supervision of the Laboratories' engineers, and shipped to Chicago. These must be exact duplicates of the safes which the manufacturer intends to place on the market under the label—in case he gets the label.

Ultimately, these test samples arrive at 207 East Ohio Street, Chicago. The engineers begin by examining the burlap and excelsior protection and the heavy paper wrapping. The safes are moved with levers, lifted with jacks, and otherwise handled by both skilled and unskilled labor, to determine the extent to which they are affected by such usage. The engineers closely examine the exterior finish, especially at all joints, for evidence of racking or distortion. They then work the doors and locking mechanism a number of times to determine how smoothly and easily these can be manipulated. This is done with the safes resting on all four wheels and then with two opposite wheels raised by steel plates. Definite upward and downward pressure is exerted on the opened doors and, in every case, the examiners use dynamometers or other measuring instruments, and little dabs of soft putty to note the accuracy of the fits at door edges.

Such installation and operation tests have a direct bearing upon the manufacturer's statement of claims as

to workmanship, suitability of materials, the form and arrangement of parts, durability, rigidity, strength, uniformity and ease of handling, shipping and maintenance.

Following these preliminary tests, one of the samples is put through Fire Test Number One, known as the "Explosion Test." This takes place in an open field.

Arriving there, the spectator sees the safe raised knee-high on four brick piers and surrounded on three sides by an eight-foot wooden fence. Magazines and loose papers have been placed inside and on the top shelf stands a recording thermometer. A camera is set up in front of the opened safe and a photograph is taken of the contents. The doors are closed. Once more the camera shutter clicks. Then kindling wood and excelsior are placed under and around the safe according to a standardized plan, an eight-foot square section of fence is nailed across the front so that the safe is completely enclosed, and additional sticks and boards are thrust into the huge box, completely covering the safe; in all, five thousand pounds of combustibles are used. Finally, thirty gallons of kerosene are poured over the whole and the match is applied.

The fuel has been so arranged as to produce the maximum of heat in the minimum of time, in order to represent extreme conflagration conditions such as a fire in a chemical factory or a lumber yard might give. Under such conditions of swiftly mounting temperature safes have been known to develop explosive interior gases; in some

cases, the doors have been thrown for many feet. Therefore it is important to search out any such tendency.

In this test, the smoke clouds are quickly succeeded by roaring flames, and, in less than three minutes, the temperature exceeds a thousand degrees; five minutes later it is fifteen hundred degrees and, in fifteen minutes from "cold," it has reached seventeen hundred degrees.

The fire swiftly burns itself out and, at the end of half an hour, the blackened safe can be seen perched above glowing embers. The engineers allow another ten minutes to pass, then play a hose over it and make a thorough survey of the external condition, measuring the bulgings of the plates with steel squares and other instruments. A sufficient degree of bulging is rated as an "explosion".

3. The Endurance Test

Following the Explosion Test comes the still more important Fire Test Number Two, or the "Endurance Test". Its main purpose is to permit the classification of safes according to the length of exposure to a standard fire (note the word "standard") which they are able to endure before their interior temperature reaches three hundred degrees—a temperature obtainable in a kitchen oven, and one that will not injure paper.

Four classifications are recognized and certified by labels, as follows:

"Class A," indicating a safe that will protect its con-

tents against a fire of extraordinary severity—four hours of furnace heat with the interior temperature rising at the standard rate (again note the word "standard") but without the interior temperature reaching 300 degrees, without explosion and without the development of certain weakness specified in the Standard; "Class B," calling for the same requirements in a two-hour test; "Class C," calling for the same requirements in a one-hour test. The fourth class is designated as "Insulated Cabinet," in which the label stands for a test of forty-five minutes. In each of these cases the temperature readings continue into the so-called "cooling period" that follows the period of actual exposure to flame.

Another important requirement is that all classes of safes bearing the Laboratories' label must withstand the Fire and Impact Test, to be described later. This does not apply to the "insulated cabinets" which, while by no means weak mechanically, are designed for less severe conditions, such as use in fire-resistive buildings with few burnable contents, where there is little danger of floors giving way.

It may be of interest to go into Building Number Three and take a close-up of the Endurance Test.

The furnace itself is a box of thick masonry, and is heated by four rows of blast burners. On the outside of the walls are valves, through which it is possible to control the distribution and intensity of the fire.

READING FURNACE TEMPERATURES

Far from the heat and roar of the furnace room in Building Number Three is this Temperature Reading Station, to which the electric wires from furnace thermo-couples are connected. Through selector switches a number of readings can be taken in quick succession. This view shows three engineers watching the rising temperatures "felt" by six thermo-couples around a safe and by four more inside it

CALIBRATING THERMO-COUPLES

The thermo-couple is a kind of electrical super-thermometer employed for the measurement of very high temperatures. Its accuracy is determined by a "calibration"; in other words, its readings are checked against a standard couple by means of a recording device. This recording device bears the formidable name of "potentiometer"

The safe to be tested is brought in and prepared for its ordeal by the placing of interior thermo-couples to indicate the heat that develops within the safe. These are arranged next to the middle joint of the double doors and in the upper corners, points where there is likely to be the first penetration of heat. Then a hole is drilled through the safe's bottom for the insertion of a closely-fitting pipe through which the thermo-couple wires may be led to the indicating instruments and, lastly, two small copper tubes also are passed through the bottom of the safe. These are to enable taking of interior air samples during the test for analysis in the chemical laboratory to determine the nature and quantity of the gases generated under the heat. This has a particular bearing on the question of explosion hazard.

The safe is then pushed into the furnace, but before its doors are closed, a number of magazines, blueprints, index cards and loose papers are placed on its shelves, a proceeding easily understood by the non-technical spectator. Following this, the furnace is closed and sealed and the test is begun.

"Go!" commands the engineer in charge; the gas is turned on and the burners are lighted.

Before long, the mica peepholes in all four walls of the furnace begin to glow and through them the surface of the safe may be seen to blister as the paint burns.

As the minutes pass, the assistant engineer goes from

one peephole to another, peering keenly through and making notes of his observations. Every few seconds a voice is raised in mysterious phrases such as: "A little high in the North. . . . Low in the East. . . ."

It is the man at the speaking tube, repeating instructions received by him from the engineer at the temperature measuring station in the next room to which the thermo-couple wires lead. With every message the proper adjustments are made of valves on the four walls of the furnace. This is a matter of utmost importance; it is related to the fact that this test follows the Standard Time Temperature Control Curve in which the heat must increase at a predetermined and controlled rate. Thus it is possible to secure absolute uniformity in the tests and to place all makes of safes on a basis of rigid impartiality. Any deviation in temperature is shown at once on the switchboard instruments and is corrected by manipulating the valves.

After twenty minutes it may be observed through a peephole at the back of the furnace that the large sheet of steel forming the back of the safe begins to show visible distortion. This is a natural condition.

Thirty minutes. The attention of several visitors is called by the assistant engineer to tiny spurts of flame issuing from joints in the safe from the generation of gases within the insulation. It is indicative of good design that they can escape without doing any damage.

Forty minutes; the steel knob of the combination lock is a brilliant red—almost white hot.

One hour, and the entire visible surface of the safe has become a brilliant red.

The safe having been submitted for Class A label, is subjected to an inferno of ever-increasing intensity for three hours longer, but at the end of the four hours the heat of the interior thermo-couples as indicated on the switchboard must not be sufficient to injure the most delicate papers on the shelves.

The engineer continues to take readings, because *the furnace* remains closed for about twenty hours, until it and the safe have become cool enough to be handled. This feature of the endurance test represents actual conditions in the most severe fires. The inside temperature continues to rise slightly for a while before slowly descending. Should even one of the interior thermo-couples register three hundred degrees, though the three others were much cooler, the safe would not get the label.

4. The Fire and Impact Test

Even more spectacular than the explosion test is the ordeal which safes of Classes A, B and C must undergo, and which is known as the Fire and Impact Test, or simply as the "drop test". A safe is heated one hour, hoisted thirty feet and dropped, allowed to cool, turned upside down and again heated one hour, allowed to cool inside

the closed furnace, and then forced open to see whether the contents were injured. This is a test not only of fire-resistance but also of strength, workmanship, skillful design and correct use of materials.

If a spectator were to arrive at the furnace room toward the end of the first heat, he would see the following procedure:

Fifty-five minutes. Eight men in overalls stand by at their stations like trained gun crews. Blocks and tackles are all set to open the wall-door of the furnace and to roll out the bottom truck on which rests the red-hot safe.

Fifty-nine minutes. The engineer at the instruments inside the other building takes a last reading of temperatures, jots them down and puts his mouth to the speaking tube:

"Ready!" he calls.

"Ready!" is the answer.

Two asbestos-gloved men disconnect the thermo-couples and withdraw them white hot from the furnace wall holes.

"Ten seconds!" shouts an engineer. No one moves, because everyone is ready.

"Five!"

A man grasps the lever of the quick-shutting main valve.

"GO!"

The flames go out with a pop. There is a thud as a man rams a timber against the door prop, which is immediately

HOT WORK

"Who said this was a light-weight safe?" ask the Plant Department workers as they withdraw a red-hot safe from the furnace preparatory to the Drop Test. In a few seconds they will pass a chain sling around it so that it may be hoisted and dropped while still hot. The safe contains magazines, index cards, loose papers, and even photographic prints, all of which must remain uninjured if the safe is to receive official recognition by the Laboratories

ABOUT TO BE DROPPED

Safes undergo a terrific ordeal before receiving the coveted label of the Laboratories. This one has just been heated to a glowing red by a one-hour exposure in a gas-fired furnace, and will now be dropped on the pile of bricks from a height of thirty feet. The next day it will be subjected to another hour of inferno, then left to cool slowly, and finally opened to make sure that papers inside it have not been charred in spite of these severe trials

caught by another. The heavy door opens, causing all spectators to retreat from the burst of radiation. Workmen, crouching to protect their faces from the heat, quickly hook the wheeled truck on which rests the red-hot safe and draw it forth, then sling it with a special arrangement of chains and bars. This is done as the safe passes through the large door of Building Number Three near which the furnace is situated. Within a few moments the glowing safe is in the yard beneath a high derrick boom, to a cable from which the chains are swiftly attached.

The hoist motor hums, the steel cables tighten, the pulley creaks and the safe rises into the air. Meanwhile the derrick boom from which it hangs swings through a quadrant until the safe is plumb above a massive concrete block set flush with the flooring of the yard and covered with a heap of loose bricks.

From one of the bars of the sling that holds the safe dangles a thirty-foot chain weighted with a chunk of iron. The moment it straightens, a man yanks a rope freeing the trip hook of the chain sling.

Down comes the safe whizzing from the height of a fourth-floor window and landing with a crash on the pile of bricks. The bricks being purposely uneven to represent the chaotic débris of a real fire, the safe has not fallen squarely and one corner is seen to be badly distorted, showing the white insulation through the torn plates.

When the safe has cooled, examinations are made as

to its stability and strength; engineers look for bulgings and separations affecting the tightness of door joints and other features. Allowing for the force of the drop, any bending, breakage or collapse showing lack of requisite strength would be counted against the safe, in considering the award of the coveted label.

The next day the safe is placed *upside down* on the furnace truck and again subjected to the flames for one hour. The furnace conditions are standard—the temperature rising to seventeen hundred degrees. An engineer watches closely through the peepholes for any sign of buckling, sagging, warping, collapse, fusion, disintegration and so on. One thinks of the effects of the thirty-foot fall while the safe's outer shell was red hot.

The third day the furnace is opened, revealing the battered safe, which is rolled out and examined by trained eyes but, of course, the most interesting moment comes when the doors are forced open. Are the contents safely preserved? Are all papers still fresh, white and pliable?

They are, but even this does not satisfy the engineers, who examine the condition of the paint and enamel on the inside, especially near the joints, and the condition of every feature. Then an autopsy is performed; workmen take the safe apart, dissecting it as a coroner would a corpse. Samples of steel and insulating material are taken from various points and subjected to chemical and physical tests. Nothing is overlooked.

This dissection of safes is performed after all fire tests, not only on the Class A, B and C safes, but also on the "Insulated Cabinet" label safes.

From the foregoing it is apparent that with safes, as with every other product inspected and tested by the Laboratories, a definite plan of investigation is followed with a view to obtaining exact and significant information; this includes examinations of materials; explosion test, drop test and endurance test. The whole plan is clear and simple and its headings are as follows:

Practicability—of handling and shipping; of installation; of operation; of maintenance.

Durability—wear and tear; sweating and swelling; corrosion.

Strength—of part; of assembled safes.

Fire Resistance—flame resistance; heat resistance.

Uniformity—of parts; of assembled safes.

These few lines stand for many hours of intense research work, into which we have given only a few glimpses.

Then follows the Report to Council as elsewhere described (page 267).

5. *The Follow-up Work*

When the votes of the Fire Council members have been found to be favorable, the safe in question is awarded its classification label, and the manufacturing company

now comes under the supervision of the Label Service Department with its inspectors.

The Laboratories' follow-up work on safes, assuring the strict maintenance of quality, is extremely detailed, painstaking, comprehensive and severe. For that matter the inspection work on fifteen thousand other products is all these things; but it is remarkable how many different items a Laboratories' factory inspector looks for in such an apparently simple device as a safe. For example, in the matter of insulation, the inspector must check up on the materials in order to make certain that they comply with specifications. This involves tracing shipments and forwarding samples to Chicago. He also examines a number of safes at different stages of their manufacture, and measures the thickness of the insulation in the sides, top, bottom, and doors. He makes sure that the insulating materials are disposed within the walls in the manner specified for that particular make.

Close inspections are made of hinges, bolting mechanism, locks and casters, as to their design, method of attachment and other features; the finish of the metal parts, both interior and exterior, is another item, and even the interior fittings are carefully inspected. The important matter of workmanship is not left entirely to the judgment of the inspector, but under it there are mentioned specific items, and the handbooks even prescribe the method by which certain fits and clearances are to be determined.

Inspectors' reports are all received at Chicago, where the labeled safe manufacturing industry is thus followed up. Inspectors are kept informed as to conditions that they should know about. For instance, if a strike were to occur in an industry upon which the office safe industry is dependent for certain raw materials, all inspectors concerned would immediately be notified to make sure that the supply of these materials does not fall below the required standard.

Once a year, and sometimes oftener, safes of each model and make are purchased secretly in the open market and shipped to Chicago for examinations and tests which are just as complete as the original acceptance investigations and tests. This is a final and positive countercheck on the Laboratories' own factory inspection work as well as on the maintenance of standards by the industry.

These are some of the reasons why the little brass label that denotes the results of these arduous and painstaking processes is coming into general recognition as the one means whereby the purchaser of safes may receive advance assurance as to their *emergency* qualities.

CHAPTER FOURTEEN

Making Burglary More Difficult

1. Matching Wits with Burglars

IN THE winter of 1920-21 an epidemic of burglaries in Chicago led to a conviction in the minds of many that "something" must be done—something more than the usual activities of police and law courts. The burglars of Chicago, always enterprising and skilful, were growing bolder. Clearly they were not deterred by the relatively small chance of being sent to jail; clearly, also, they were not efficiently resisted by the thousands of locks and burglar alarms. These things might have been good enough for an earlier day, but the burglar's mind is acute, ingenious and enterprising; he experiments, tries new ways, and tells his pals when successful. Thus, knowledge accumulates, as in any other learned profession, and stationary resistance methods cannot long cope with advancing methods of attack.

By the winter of 1920-21, as already stated, there had grown up a conviction that another step must be taken, and this took the form of requests from manufacturers and insurance men that Underwriters' Laboratories assume the writing of "Standards" on various means of

protection. Burglar alarm systems had been used for about thirty years, but seemingly without much improvement in the average protection afforded. This was due largely to the fact that prospective users were at a loss in choosing from many equipments, because there were no "standards" of design and construction and no scientific discounts on burglary insurance rates. The same thing was true with regard to vaults, safety deposit boxes and locking devices.

This, indeed, was the crux of the difficulty. Inventive brains had not been idle, new products were forthcoming from time to time, representing various degrees of ingenuity and efficiency, and in each case enthusiastic manufacturers claimed, no doubt sincerely, that the problem of burglar resistance had been solved; but how was one to be *sure* until the product was tested by some skilful cracksman—and then it might be too late. The situation cried aloud for the obtaining of exact information, for tests to be made by the most highly proficient burglars, at times and under conditions when property would not be imperilled, with resulting classification of a thorough and impartial nature. Proficient burglars, it found, could not be trusted, hence, proficient "burglars" must be developed out of men who could be trusted, and their equipment must be equal to the finest at the command of the artists of the underworld.

The situation differed in one important respect from

that of the fire protection investigations discussed in preceding chapters; it involved a contest, not with natural forces, but with human ingenuity and daring. It was, in short, a process of matching wits with burglars.

The first positive steps were taken when the Burglary Insurance Underwriters' Association ruled that future installations would be recognized by reduced rates when reported upon favorably by Underwriters' Laboratories, and when manufacturers of protective devices met at the Chicago and New York offices of the Laboratories in May, 1921, and pledged their support. At about the same time there was formed the Burglary Protection Council of the Laboratories, and the work was formally inaugurated in September. By the end of 1921, no less than forty-seven systems and devices had been submitted. The Laboratories was fully prepared, having begun about one year previously to develop a staff of experts in burglary protection.

It was not long before engineers at both the Chicago and New York testing stations astonished manufacturers of supposedly impregnable systems by "burglarizing" simulated business premises with apparent ease: They had already found weak points. But that was not enough, they suggested specific improvements, which were adopted one by one. A number of confidential reports of criticism written to manufacturers brought back evidence that the industry was alert to profit by

the technical study given to its problems by Underwriters' Laboratories.

It was quickly appreciated that even the most skilful and determined burglar needs more than the cover of darkness: He must have time to accomplish his design, and security from knowledge of his presence. Therefore the problem of burglary protection resolves itself into two phases:

First. Prevention or interruption of the attack, through immediate detection of the burglar's presence.

Second. Mechanical resistance to the attack.

These are the fundamentals of the investigations now in constant progress.

The first phase involves the use of alarm systems, with indicators, gongs, tell-tale lights, or other warnings supplemented in cases by the summoning of armed guards; while the second calls for effective locks, bars, plates, boxes, doors and vaults.

All this comes under the problem of protection against the burglar, who is essentially a secret worker, but there is also the necessity for defence in the case of armed daylight bank and store robbers. Against the latter there have been developed special protection systems, with sounding devices to bring reinforcements from the street. These may be considered under burglar-alarm systems, with which they are often combined.

It is the function of Underwriters' Laboratories to de-

termine the effectiveness of all such means of protection as are submitted to it. The first group of devices and systems must be absolutely reliable, for an alarm that does not always work is worse than none at all. The second group can never furnish absolute protection; their value consists in the time required to defeat them, and, in this group, the Laboratories determines the degree of resistance offered.

In coping with the problem of protection from burglars, first attention must be given to their prompt detection; in other words, to the alarm system. If this be adequate there may be no need for calling into play the burglar-resistant qualities of the safe, strong box or other container of valuables. Consequently it is recognized as folly for banks, jewelry stores, and other places where valuables are stored, to neglect this form of precaution.

Various are the methods adopted. Windows and doors are wired; glass panes are decorated with tin-foil ribbon apparently for ornament but really to carry an electric current as part of the system of protection; window and door openings are filled with wooden lattice work, so wired as to send in an alarm at the least disturbance; alarms are concealed under thresholds and floor rugs; they are connected with show cases and vaults; they find expression through horns, sirens, gongs and lights, or in indicators at some central station; ingenious burglar traps are thus spread every night in thousands of

business places, and in not a few residences as well. No one realizes this better than does the cracksman. If he is to succeed at his chosen calling he must keep abreast of developments in the art of protection. Hence the skilful operators of a generation ago became adept at locating and cutting the electrical connections of these alarms. To circumvent them the manufacturers thereupon devised alarms in which the electric current was continuous while in use, so that its interruption would give warning. Burglars countered this by having batteries which could be connected with the system in order to continue the current while the main connection was being broken, and the manufacturers thereupon produced alarms sufficiently delicate to register the effect of a variation in the strength of the current such as would be almost certain to occur between the regular supply current and that of the portable battery.

Thus in various ways the contest has continued, and while burglary is thus made difficult and often reaches a capture, it still is successful in an amazingly large number of cases. For this reason the wise merchant or householder carries additional protection in the form of burglary insurance and the problem thus becomes vital to the insurance companies. Through them it logically becomes a concern of Underwriters' Laboratories, for a company in assuming risk must make sure that the protective systems in use are as efficient as they can be made.

2. Grading the Alarm Systems

It is natural that alarm systems should be of many different kinds. One used to protect a bank vault may cost as high as $5,000 or $10,000 and should be able to last for a number of years without calling for repair—especially as to its electric lining, which usually is embedded in concrete walls. On the other hand, a mercantile alarm system cannot be too costly, because small establishments usually hope to outgrow their premises; and also because the walls, floors, and doors and windows of ordinary business premises are not sufficiently resistant to warrant elaborate systems; that is to say, a common burglar could quickly "smash, grab and run" whether the system were simple or elaborate. Another consideration is that protective devices are frequently portable and almost always exposed. Take-down screens are sometimes placed in the way of porters who may shove boxes against them. They must be replaceable at small cost. Thus a comparatively new but active branch of the Laboratories' work is constantly dealing with a great variety of protective devices for purposes of classification and label as in the other departments.

Alarm systems are classified in two ways: First, as to kind of risk, into *Bank alarm systems*, which must be very sensitive, durable and in many ways highly refined; and *Mercantile alarm systems* which meet somewhat less

exacting requirements. The second classification is into *Local systems* which are self-contained, and *Central Station systems* which are connected to an office from which patrols are rushed when the signal is flashed.

Every system is graded according to a schedule of credits. It must "pass" its examination, like a small boy in school or a candidate for a civil service job. There are certain credit points for each of the necessary features, and if the system does not win a sufficient number of these points, it does not secure its diploma, i. e., the listing.

A local mercantile system which wins less than 500 points out of 1000 gets no recognition at all. From 500 to 700, it is graded "C" and the minimum requirement for Grade "B" is 700 points. For central stations and bank systems there are similar schedules, but the requirements are stricter. Those for bank systems form a lengthy document which covers hundreds of items. Central station systems present an additional factor, for the physical equipment is supplemented by the service rendered or supposed to be rendered by the company. As to the latter, claims made in advertisements count for nothing; the basis of the grading is performance. For instance, to get at the important item of "average elapsed time in answering alarms," engineers not only go through the company's records but remain night and day with its forces.

In order that a system may be listed by the Laboratories, its follow-up supervision as in all other lines must

be agreed to by the company. Underwriters' Laboratories' supervision includes the usual periodical inspections at factories, as to materials used, workmanship, uniformity, etc. In addition the Laboratories keeps on examining various installations in use and making inquiries, to countercheck the service rendered by the alarm company.

3. A Typical Local Mercantile Alarm System

The most easily understood type of alarm system is the "local" and the simplest classification recognized is that of "mercantile". But even in a local mercantile system there are several broad requirements *all* of which must be met. These are as follows:

First. It is not sufficient for a system to be well designed and well made; it must be maintained in good order by the company.

Second. The rods or wiring must not be far enough apart for the burglar to be able to spread them and crawl through.

Finally, the gong or siren must be heard at least five hundred feet under favorable conditions.

These three requirements seem obvious, yet many devices on the market do not possess them all. This is one of the principal reasons for the Laboratories' investigations. In testing a submitted system, the engineers study first of all its general design and construction. Occasion-

ally they tell the manufacturer at this point that unless certain improvements are made further investigations would be a waste of time.

Next in order has come the consideration of the system's practicability as to its installation, use, and maintenance in business premises—a matter of considerable work.

Following this, there are a number of laboratory tests, most of them made to determine the durability of the various parts of the system as well as of the entire installation unit. As an instance of the durability investigation there may be taken the case of a glass pane protected with tinfoil ribbon applied near its edges in an ornamental way. The manufacturer has supplied several of a standard size, and the engineers, disregarding their beauty, put them through a strenuous experience.

One pane is taken to the vibration apparatus, and its foil is connected so that a buzzer will sound when a break occurs in the circuit. The pane itself is held loosely in steel grooves, and the loose play is increased until it rattles as much as one-tenth of an inch. At the end, if the buzzer has remained silent, observations are made nevertheless for any looseness that will indicate faulty method of foiling.

Another standard foiled sash is clamped vertically and washed twelve times, with hot and cold water and common cleaning compounds such as ammonia, scouring soap, etc. This rarely results in a break in the circuit

but the engineers always look for scratches, discolorations, turning-up of edges of foil strips, etc. Then come tests by moist heat, dry heat and others reproducing conditions of service, and, finally, the burglarious attack tests.

One of these consists in a number of attempts to muffle the gong or otherwise to put it out of commission. This is what many burglars try first to do, and, in duplicating their efforts, the engineers make use of clay, tarpaulin, liquid or other materials. As everyone knows, these gongs are frequently enclosed in boxes so wired that tampering will ring the gongs. In making this test, the housing is set up and connected as in use. One of the Laboratories' experts, familiar with it—as burglars may be—and provided with proper tools, announces his readiness. "Time!" calls the observer. The "burglar" works swiftly, skilfully, and without noise, because this is an "expert premeditated attack". Suddenly the gong shatters the silence. "Fifty seconds," comments the observer. A second method of attack is tried, but just as the engineer seems able to insert a stick in the housing the gong clangs once more. Foiled again! Is this device burglar-proof? Not yet, for the expert smiles and tries a third method, which proves successful. A confidential report containing suggestions will be sent to the alarm company.

After using methods involving skill and knowledge of the system, others are tried, representing the efforts of unskilled burglars. These "amateur" attacks consist in des-

FORESTALLING THE "YEGG"

The man on the ladder is not a bank robber, but a Laboratories' engineer. He is using one of the favorite methods of yeggs in attempting to gain entrance to a protected vault by first silencing the alarm. In this case, it is necessary to reach the gong by cutting through its housing with an oxy-acetylene torch. The purpose of the test is to determine how successfully the housing can resist such an attack

ATTACKING A BANK VAULT IN THE NEW YORK OFFICE

Will this "burglar" be able to disconnect the powerful gong inside the alarm housing without breaking the protected wiring under the steel louvres and thus setting off the alarm? The fact that he is an expert of the Burglary Protection Division of the Laboratories leads one to think that the particular system under investigation will be subjected to quite a severe test; and the severer the test the higher the rating officially awarded to the system that passes it.

perately speedy drilling, sawing, chiseling, hammering, prying, and so on. All this work is attended with more or less suspicious noise, and depends for its chance of success upon the speed with which it is carried forward. This taking of time is therefore an important part of the test.

The next series of attacks is made upon the protection wiring. This may at first appear to be impregnable, but engineers thoroughly acquainted with the system now get to work and eventually are able to pass through without sending an alarm. However, if it prove to be a long and difficult process, the system is regarded as affording much more than the usual degree of protection.

Where electricity is involved, the fire hazard cannot be overlooked, for no business man wishes to pay for burglary protection the price of a possible fire. Underwriters' Laboratories therefore investigates and tests the system from that angle.

In addition to laboratory work, the engineers look over the materials and workmanship of existing installations by the alarm company, make tests at these points and ask the users many questions about attempted burglaries, trouble calls and their causes, false alarms, and the frequency and extent of the inspections made by the company. Such inquiries are supplemented by correspondence with other users. Inspections are also made at the factory itself, to determine the suitability of the equipment used in the manufacture of the system, and other

points that would affect the ultimate protection afforded by the system as manufactured.

4. Central Station Burglar Alarm Systems

The "central station" systems lay an especial emphasis on the well-known human equation. Of what avail is it for the burglar to incite the alarm and for the alarm faithfully to register that fact in a central station, unless there be a speedy response by able and courageous guards? Here, indeed, is a class of investigations so complicated and technical because of the factors it involves, that no attempt will be made even to give its headings, more than to say that it concerns both the physical equipment and the protection service.

In their usual meticulous fashion, the engineers put all the physical elements through the necessary tests, and to this study they add that of the *forces* employed by the company, inside and outside, clerical, technical and special —their selection, experience, qualifications and special training, and their sizes and distribution: the *equipment* of the guards and the travel facilities provided for them and the relations of the company with the *police* department of every city in which it operates central offices.

Perhaps it might be the most interesting method of description to work backward from this last item.

Police Relations. The engineer assigned to make this study begins by looking through the company's records

bearing on this subject. Police officials are then interviewed and facilities obtained for gathering data on eleven sub-topics, among which are the following: Whether there is a well-defined relationship between police and company; whether the police give preference to calls from the company; whether the handling of these calls is a matter of routine or are they handled in any special manner; whether the relations are subject to change with changing administrations; whether it is the same in all precincts; whether it is the same in different cities covered by the company, and what provisions are made for giving the right of way in traffic to the company's automobiles rushing to answer signals?

Size and Distribution of Forces. This study includes obvious items like the distance from central offices to subscribers, the number of operators and of guards at various times, how long it takes guards to report back, and the number of subscribers' lines at each central office.

The Company Itself is considered not only as a firm which manufactures, installs and maintains electrical devices, but also as an organization in which great confidence must be reposed by subscribers and the investigators make searching inquiries.

Laboratory Tests. Every part of the system is subjected to various tests, and the system as a whole is also made to prove its degree of impregnability, sensitiveness, positiveness and other qualities. There are also tests to

reproduce the attacks of skilled and unskilled burglars, familiar or unacquainted with the system. Other possibilities investigated under "defeat of the system" are those of overpowering guards by force and of breaking into premises and getting away before the arrival of guards.

Inspections and Tests at Installations. Actual installations are selected, and whenever practicable, the engineers first close the place to represent night conditions. For convenience, they always take along and connect a portable signaling device, although in certain tests communication is also established with the central office.

Every entrance test possible without injury is made on these existing installations but, where necessary, the engineers do not hesitate to make attacks which require simple repairs. They never fail to note how far doors, transoms and windows can be opened without signal to central, and whether a burglar who does so can "fish" for valuables with a stick and hook or other device. Nor do they leave without trying to create false alarms by shaking, pressing and jarring doors and windows.

5. Mechanical Resistance

We have already said that the Laboratories' engineers have acquired the art of judging the weak points of anti-burglar devices from the standpoint of the skilled burglar. Sometimes a device is submitted which has been studied from that standpoint but in which the engineers discover me-

chanical weaknesses, thanks to their wide experience in other lines. For instance, the manufacturer of a show window steel shutter which was supposed to drop immediately if the plate glass were broken was told at the Laboratories that there were needed "almost a hundred and one improvements." He disregarded the advice and sold his device. Not long afterward, a burglar broke a show window which had been equipped with it, and helped himself to displayed valuables, while the apparently unconcerned shutter stayed up. The next day the manufacturer came back to the Laboratories in a penitent mood and listened respectfully to the engineers' advice. In another case a manufacturer was eager to bet that his lock could not be defeated. Fortunately for him the engineers do not take bets, for the lock was opened in just ninety seconds.

In Chapter Sixteen the testing of automobile locks will be described. It is typical of the testing of all locks.

Safety deposit boxes are received from the manufacturers in typical sections of from twenty to fifty boxes. Using various tools, several methods of entrance are devised—some attended by noise and others almost silent. Each method is used on several boxes, and by the time every box has been entered and the results analyzed, the engineers are able to judge of the degree of their resistance.

An interesting class of mechanism is that of "relocking devices," used mostly on bank vault doors. Their purpose is to foil burglars in an unexpected way: When a hole

is drilled in the steel plate, or cut with a torch, or when the combination is dynamited, or punched out with a sledge, there is a click and the bolt bars are doubly secured, so that the burglar would have to cut a hole large enough to pass through in order to get in. Of course, the next morning the bank must send for a mechanic to release the relocking device and allow the normal opening of the door, but that is little enough trouble for the extra protection afforded by the device.

In examining these devices the engineers proceed as engineers, but in testing them there is but one effective way—and they follow it. They break in! When they get through, the goods under test are fit only for the junk dealer, but the result is that the grade of the relocking device has been scientifically determined under the many and minute requirements of Underwriters' Laboratories' standard.

6. *False Alarms, "Super-Burglars" and "Yeggs"*

That the foregoing tests are not made in a spirit of over-fussiness is proved by the police records of every city. The rewards of burglary have been altogether too large in proportion to its perils, and the safety of the public calls for every possible effort to cut down this class of crime. If it be argued that many of the tests are directed against the operation of the super-burglar it may be answered that this class of gifted specialists is responsible

"RED HOGAN" AND THE "OMAHA KID"

These are not really the names of these two perfectly respectable members of Underwriters' Laboratories' staff, but they are using methods that are frequently employed by yeggs on fire-proof vault doors. In this case a relocking device is under test in order to determine whether its degree of burglar resistance entitles it to receive official recognition by insurance companies

ENABLING BANKERS TO SLEEP PEACEFULLY

With so many expert bank burglars at large it becomes important to make sure that bank vault burglar alarm systems cannot be silenced or otherwise defeated even by skilled yeggs working from Saturday evening to Monday morning. This picture shows one of these systems, completely assembled and set up to represent conditions in a bank, being "attacked" by two of the Laboratories' experts, to determine just how much reliance bankers may place in it

for many of the biggest robberies and is a constant incentive to his lesser brethren.

On the other hand, it is doubtless true that cruder criminals, like the "yeggs" and the "snatch robbers," constitute a much greater menace because they are so much more numerous. From the very simplicity and quickness of their operations they are extremely hard to deal with.

Such men do not try to defeat alarms; they simply plan to get away before the alarm is answered. In a recent fairly typical instance, the same store was robbed four times within two months, while policemen were only two blocks away. In each case, the thieves watched their chance, smashed the window with a padded brick, grabbed what was within reach and made their escape by automobile. The alarm operated, but quick work made it possible to get away.

In the robbery of a New York warehouse the robbers evidently knew the exact limits covered by the alarm system reporting to a central office. Going in a motor truck to a point as far away as possible from the building they expected to rob, they broke a window with a brick, thus sending in an alarm, and sped on to their real objective. The first alarm sounded in the central office and armed guards were at once dispatched in a waiting automobile. But on reaching this place, they found merely a broken window which they reported on their return to the central office. In the meantime, the second alarm had

come in from a point a number of blocks distant and before the guards could reach this second point, the robbers had had six minutes in which to make their haul.

For such reasons, many inventors are now working on efforts to combine alarms with apparatus for furnishing resistance, in order to delay the burglar while the alarm is being answered. Thus the battle of wits progresses.

One of the greatest obstacles to the success of alarm systems is the fact that so many of them operate too easily; in other words, they signal when there is no attack. In one central office it was estimated that there were forty-nine false alarms to every one that was due to thieves.

Such conditions, naturally, are demoralizing. One of the engineers of Underwriters' Laboratories, in making a California inspection, caused a store alarm to be sounded, then stood within the window and watched a policeman who was about twenty feet away. The gong rang steadily for five minutes and the officer never even turned his head. Later he stated that he paid no attention to alarms because they were "always ringing".

The elimination of non-attack alarms is one in which the Laboratories is much interested.

What then is the result of all these painstaking labors? Are they of any use, the cynic may inquire, since almost every paper chronicles new and successful burglaries? Why not simply concede that the thieves have the best of the battle of wits, and save the trouble and expense of

toilsome tests? To such questions it may be answered that the tests are still too new for their results to have been applied in more than a small percentage of their total possibilities. Furthermore, as is true in the case of fire, it is one thing to prevent *burglary*, considered in the abstract and aggregate, and quite another thing to prevent individual *burglaries*. This latter result has most certainly been attained in very many cases.

The products of American inventive ability, selected and classified by scientific tests that have only recently been made available, and backed by an incentive in the form of reduced rates for burglary insurance, should lead, in time, to the wide installation of approved devices, and then ultimately to a marked reduction of burglary itself.

CHAPTER FIFTEEN

Protecting Life and Limb

1. Playing a Double Rôle

THE prevention of accidents in this world of chance —what could seem like a wilder, more impossible ambition for an institution like Underwriters' Laboratories? However, it is not well to jump to conclusions. The idea is reasonable; it is even meeting with a fair degree of success.

The key to this extraordinary statement is to be found in the letter "s". There is a wide difference between "accidents," the plural word meaning few or many accidents, individually considered, and "accident," which stands collectively for them all. Individual accidents are being prevented in unaccountable numbers but the sum total of casualty is still enormous. Even so, its limitation in certain directions is already pronounced. Of the many forces contributing to this end none plays a more vital part than Underwriters' Laboratories.

As in the case of fire prevention, this part is physical, not psychological. Careless people will continue to have accidents in spite of all safeguards, and must be reached through education, example and even legislation, as is

now being undertaken on so large a scale, but there remains an important field of protective effort in reducing the hazards of the devices and materials employed by man in his daily life.

Safety to life or limb calls for the use of equipment or methods that are *devoid of natural hazard*, or that are *provided with proper safeguards*. In its casualty work, therefore, Underwriters' Laboratories plays a double rôle: it certifies a low degree of hazard in devices belonging to classes which naturally are dangerous; and it determines the degree of protection afforded by those appliances whose purpose is to provide safeguards.

Incidentally, it may be noted that the work of the Casualty Department overlaps that of the others at many points, and it even sometimes happens that a device intended to counteract some other hazard may unwittingly introduce a new casualty hazard. Consequently, the Laboratories never fails to consider the possible accident hazard in whatever form of device may be under investigation and, conversely, it never fails to consider other possible hazards whenever a device is submitted for accident rating.

2. *Ladders and Other Things*

"The total depravity of inanimate things" has passed into a proverb and perhaps none of these has borne a worse reputation throughout the ages than the ancient and uni-

versal ladder, which therefore has become a subject of much study at 207 East Ohio Street.

Slippage being the principal cause of accidents, inventors have devised various forms of ladder *feet*, of which several kinds have finally won recognition by the Laboratories. To quote from its statement about them:

> No one type of ladder foot has been found suitable under all conditions of service. Many different types have been developed and the type best suited to service should be chosen.
>
> In general it may be said that for use on rough or wooden floors, ladder feet having one or more sharp spikes, or having flat, lead-coated bottoms will be found suitable. For use on wet and relatively smooth floors, ladder feet having recessed rubber bottoms have been found of service. For use on concrete and rough iron floors, ladder feet having contact surfaces in which particles of abrasive substances, such as carborundum, are partly embedded have been found suitable. Ladder feet having lead-covered bases are also suitable for use on concrete floors.
>
> Ladder feet should be renewed when worn or otherwise kept in proper condition in order to perform their proper functions. Spiked feet will wear and lose their sharpness. Suction-grip feet depend on an even contact of their bottoms surrounding the recessed portions so as to exert a suction effort; accordingly wear and damage resulting in unevenness may soon destroy their effectivenes. Lead-coated feet may wear or become smooth and offer less slipping resistance. Abrasive-studded feet may have particles of abrasive broken off or may become clogged with foreign material and thereby lose their effectiveness.

Such were the conclusions of probably the most searching inquiry into the subject of ladder slippage ever made.

So much for ladder feet, but grades of materials, and the form and dimensions of stringers, steps or rungs, braces, hinges, spreaders, extension mechanism, and other features are studied with equal care before the labeled ladders can be offered to the public. The purchaser may realize that if he have an accident it is his own fault.

Another man-made product quite indispensable in its service, but with a bloody record, is glass. There is hardly a person who has not had repeated encounters with the sharp edges of broken glass, and its capacity for harm needs no emphasis. Sometimes, as in the case of broken wind-shields in automobile accidents, the injuries inflicted may be serious, even fatal. This also is true, in marked degree, with the falling fragments from upper windows broken by the heat of fires or explosions. At the time of the bomb outrage in Wall Street in September, 1920, glass fell in a shower from hundreds of windows, and inflicted some serious injuries in the street below.

From the standpoint of both fire prevention and accident prevention there have been many efforts to obviate this hazard in a material of such universal necessity, and various products made in conformity with these ideas have come before the Laboratories for investigation. Foremost among these, of course, is the now familiar wired glass, in which the mesh retains the fragments resulting from cracking. This is generally recognized as one of the most important developments ever made in the fire-proofing

of buildings. The same qualities that make it valuable for this purpose have their bearing upon the elimination of accident hazard; in fact, in the case of the Wall Street explosion, wired glass windows in some of the buildings were the only ones to retain their place, although the glass itself was cracked by the force of the concussion.

There has also been much experiment along other lines, particularly in the search for a practical non-breakable glass, which still seems a distant ideal; but considerable progress has been made through the production of the so-called "laminated glass". One type of this product is a kind of glass "sandwich," being made of two layers of glass with a sheet of pyroxalin plastic or some other transparent material placed between.

This latter kind of glass was submitted in 1916 after having been eight months on the market as automobile wind-shield and window glass, and the makers, claiming that it had hundreds of other uses, desired that Underwriters' Laboratories certify its advantages over plain glass. Among other points in their claim, they said that a powerful blow would cause a cluster of hair-line cracks but not sufficient to penetrate it, leaving it still a perfect protection against the weather. "This property should make it valuable for instruments on which safety to life depends, as on board ships." Another interesting claim was that it was "practically burglar proof".

The Laboratories' engineers devised a number of tests,

most of them made alternately on the submitted product and on plate glass of the same thickness or weight. There were static strength tests on samples supported at the ends and subjected to increasing measured pressure at the center, which showed, after mathematical computations had been made, that the invention was stronger than plate glass. But the most interesting were the impact strength tests in which the new product was compared not only with plate glass but with wired glass, as to resistance to falling weights such as pieces of lead or one-pound steel balls. The quantity, appearance and weight of the fragments thrown off were carefully observed and those thrown off by the laminated glass test specimens were found to be much less than those from wired glass, while the plate glass samples were "completely shattered".

Thousands of factory accidents have come from the use of belting, particularly in the matter of breaking and shifting. As to the latter, safety shifters have been devised and are made a subject of study by the Laboratories.

Good safety belt shifters cost from fifteen to twenty-five dollars and that is one reason why they are not universally used, but an even stronger reason is that mechanics do not take to them; they prefer to enjoy performing the trick of shifting by hand, which is one of the first things the young apprentice learns. In old-time shops, youngsters were not allowed to shift belts; they would have to call one of the old-timers, and stand in ad-

miration while he expertly flipped the belt from one step of the cone pulleys to the other. Having at last acquired the knack (perhaps after one or two narrow escapes) a man would naturally scorn to use the "fool protector".

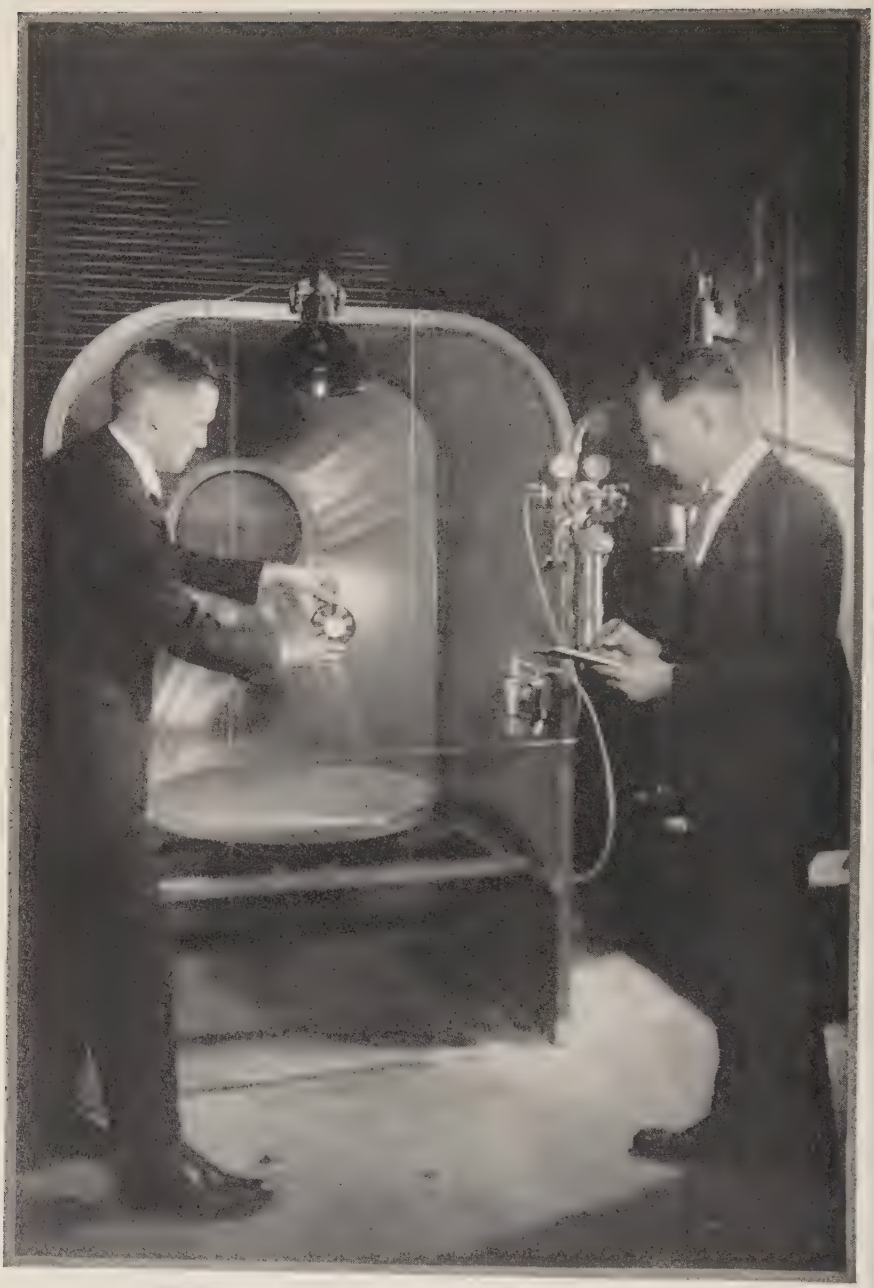
The breakage of belts is largely due to improper lacing or fastening, hence machines for fastening the ends of belts are of great importance. Imperfect fasteners also account for severe lacerations of hands. Those that are listed by the Laboratories have been carefully tested, and are carefully kept up to standard by factory inspections.

Another example of a mischievous inanimate thing is the common set-screw, which is harmless enough when used to fasten two motionless parts, but is a source of danger when it projects from the surface of a fast-revolving shaft, collar or coupling. There are safety set-screws which need not project, because the usual slot is replaced by a square or hexagonal cavity, and the Laboratories has listed them, but as always their adoption is slower than insurance inspectors would like to see it. One of these inspectors was urging their use during the course of a discussion with the superintendent of a large factory in New York State, and he pointed out as almost criminally hazardous one old-fashioned set-screw projecting from a shaft near a narrow passage. "Nonsense," ridiculed the superintendent, "that shaft and screw have been turning there for fifteen years."

"Then, according to the law of averages," exclaimed

WIRED GLASS AND THE WALL STREET BOMB

The terrific explosion of October, 1920, caused the glass from hundreds of windows to fall in a dangerous shower to the crowded sidewalks. Plain glass windows in the same suite of offices where this picture was made were completely destroyed, but windows of wired glass remained intact although extensively cracked



RECORDING AIR VELOCITIES IN SPRAY PAINTING BOOTH

"Spray guns" for applying paint are used in many industries, but this process releases inflammable vapors which must be removed from the room. Here is a metal booth provided with a suction fan, designed to make this work safe by exhausting the dangerous vapors. It is important that the air flow inward at *all* points, hence, the front of the booth is divided into sections, and the air velocities are determined at each of them by means of an accurate wind-gauge

the insurance man, "you are due for an accident. For God's sake take it out!"

The superintendent laughed heartily, but shortly afterwards his own clothing was caught by the self-same set-screw, so that he was whirled around by the shaft and badly injured.

In too many cases, it is good luck rather than good management which has "prevented" accidents.

Punch-presses are easy to operate, and boys and girls as well as "birds of passage" and "floaters" are often employed on them. They all must be safeguarded against the results of their own ignorance or carelessness. Another psychological factor in the operation of punch-presses is that so great is the force of habit that when the worker's attention is distracted, he or she will often continue to press the pedal every two or three seconds, while using the hands for something else. One girl, working on a press which was "guarded" only from the front, saw something wrong, quickly reached around the unprotected back, and then, through force of habit, put her foot on the pedal, with the result that her thumb was cut off. Any *complete* guard would have prevented this accident.

Ladders, glass, belts, set-screws, punch-presses . . . . these few examples seem insufficient as illustrations of the Laboratories' activities in the reduction of inherent accident hazard, but space limitation forbids more than

one additional example, which may well be that of the scaffold—not the hangman's scaffold, but the ordinary builder's contraption—which has cost a far greater number of human lives; indeed, on some buildings defective scaffolding has caused an average of one death for each floor. *Labeled* scaffolding machines are so simple and obvious in design, that one may well wonder why such methods were not adopted generations ago. Here again it is made evident that humanity wins forward slowly and haltingly because every step taken involves the conquering of some deeply-intrenched habit.

Safety scaffolding machines come *in pairs*, and are arrangements of flexible cables, winding drums, guard rail supports, toe boards and lesser parts mounted on angle-iron "putlogs" on which rest the ends of the scaffold proper—suitable planks supplied by the builder. Their operation, too, is so simple that bricklayers and stonemasons, who are notably slow to learn "machinery," hardly need to be taught how to use them. The Laboratories' work of certification, however, was far from simple. It so happened that this was the second subject dealt with by the Casualty Department, and its exhaustive report of examinations and tests, published in 1915, bears testimony to its consciousness of the burden of responsibility for the future safety to thousands of lives. It is gratifying to note the statement of one authority that *there never yet has been a fatal accident from the failure*

of labeled scaffolding. Contrast this with the ghastly record of the old type!

3. Safety Appliances

In the foregoing examples, as well as in many others, there has been the need of searching out and correcting inherent hazards, but this spells only part of the labors of the Casualty Department, for the progress of the safety idea has shown itself in a multiplicity of products whose sole purpose is that of safeguarding. These include a great variety of guards for machines and tools of many kinds—to prevent workers' limbs being caught, to prevent clothing being caught, to stop flying fragments when breakages or explosions occur, to prevent human contact with molten metals, highly heated parts or electrically "live" parts; also articles to be worn, such as goggles, gloves, respirators and window cleaners' belts and fittings, and a number of exit and "panic" appliances. Their diversity makes it difficult to speak of them in general terms: every device must be judged with regard to its peculiar function in use.

Perhaps the most complicated safety appliance thus far submitted was a fire-escape which included a small jib-crane, a supporting bracket, a steel cable, drum and other things. The whole was for window attachment and was intended to lower its user to the ground in case of fire, then automatically to rewind its cable for the next user.

In examining this the engineers dismantled it in order to note the structural details; and their report on the form and arrangement of parts, materials and workmanship ran to 3,500 words. Then followed various strength tests and even temperature tests that were made to ascertain whether the grease in the drum cylinders would become too solid in cold weather, thus slowing the descent, or would soften in hot weather thus allowing a heavy person to come down too quickly. Satisfied on this point, there were actual operation tests from a third-floor landing, during which a number of observations were made. In one of the descents, the manufacturer's representative stopped with a jerk before reaching the ground because he had shortened the cable too much. However, the Laboratories' own clean record as to "never an accident" was not marred, because the machine withstood the shock without damage or weakening, while the maker's agent passed off the incident with a laugh. But the engineers, when their amusement had passed (though the report says nothing about it), discussed this incident in technical language in their report, because it threw light on the strength and reliability of the fire-escape.

In another case an inventor wished to demonstrate his device in a similar way, but this was not permitted by the engineers because it had not been sufficiently safeguarded. A short time later he fell and was killed while demonstrating in another city.

Another complicated safety appliance is known as "an emergency discharging system for ammonia plants," and is for use in refrigerating plants. When fires occur in such plants, firemen are sometimes hampered by the fumes of ammonia, and this device is intended to discharge the ammonia harmlessly into the sewer in case of sudden need.

Among other emergency safety devices may be mentioned panic doors and panic hardware for doors, the use of which would have saved hundreds of lives in theater and school disasters which it will take many decades to forget. The Laboratories, before listing such devices, puts them through careful examinations as to workmanship and provisions for durability, as well as through practical operation tests to make sure that a slight pressure on the latch immediately and positively causes the door to open.

But the greatest amount of work is upon safety appliances and materials for every-day use. One of the simplest of these is the safety tread for stairways. Inventors came with ideas which they believed to be the solution of the slippage problems due to wear, water, or other conditions, but the Laboratories devised special testing apparatus in which mechanically operated weights, shod with leather "soles," were scuffed back and forth over the surface and the treads. After a certain number of thousand rubs, some products were found to have become

smooth and slippery while others showed little wear. The "S.A." files on this subject contain quantities of letters between the Laboratories and manufacturers, with safety commissions and other interested bodies chiming in. There are many so-called safety *stair treads* on the market, but few labeled ones. The Laboratories' engineers supplemented their tests with "field investigations," and interviewed a number of persons. Samples were also installed on the Laboratories' main stairway for direct personal experience. Even the question of lawsuits that had arisen from accidents involving certain materials was weighed, although it must be emphasized that the Laboratories examines questions of *fact*, and leaves to lawyers and judges the determination of *law*. At any rate, the Laboratories' findings were revolutionary; they stirred considerable discussion, but they have stood. And this in spite of the fact that the Laboratories purposely withheld the major portion of its conclusions on account of "insufficiency of data," and restricted itself in a "letter report" to a brief statement as to the suitability of various types for use.

Guarding devices for the protection of workers are sometimes too simple to be effective, particularly in the case of certain forms used with stamping presses. For such purpose, the ideal guard is one that is connected to the latch of the press clutch in such a way that the ram cannot descend while the operators' hands are in the

BETTER THAN LOSING FINGERS

Unguarded circular saws are the cause of many accidents. In order to protect operators, many forms of mechanical guards have been devised. A test of one of these is here being made for the purpose of determining to what degree it will fulfill its purpose

PROTECTING THE EYES OF WORKMEN

These operators do not appear to be safeguarding the eyesight of many thousands of workmen; nevertheless, that is the purport of the test here pictured. In some metal industries workers must wear goggles in order to protect their eyes from flying fragments, but poor goggles may be worse than none, since they add the danger from glass fragments. Here is a steel ball drop test which simulates industrial conditions where a flying rivet head may strike the goggle lens

danger zone. It would take too long to go through the list of machines which need guarding appliances.

In every case, the Laboratories operates the machine many times, using finger-shaped pieces of wood in attempts to defeat the purpose of the guarding device. The workmanship of the devices is also considered, and their service records carefully investigated. Almost all the devices submitted in this class have been improved by suggestions made by the engineers.

Goggles are used as protection not only against flying particles but also against radiation: intense flames and the incandescence of metals in welding operations are a source of ultra-violet rays which tend to cause the dread cataract. Samples of the various styles and shades of goggle lenses made by each submittor are examined and tested to determine their transmission of heat, light and ultra-violet radiation. At the Laboratories, "comfort" tests by a number of observers, strength tests, hot metal tests, and tests of materials are made in thorough manner.

Elevator inspection is outside the scope of the Laboratories, but a number of elevator safety appliances have been submitted and put through various tests not only at the East Ohio Street plant but at various actual installations. The reports on elevator safety appliances which have received listing always include at least one paragraph as to the conditions under which these devices are quite suitable; for instance some of them might not be

always reliable if the play of the elevator car or shaft door were greater than one-half inch. The strength and durability requirements, of course, are rigid.

In these and many other ways, the fingers and bones of millions of industrial workers and the bodily safety of all classes of the public are safeguarded through the constant study and innumerable tests made by the engineers of the Casualty Department.

CHAPTER SIXTEEN

The Safety of Cars and Their Passengers

The Start of the Schedules

PROBABLY no single industrial development of the past generation has changed conditions of life so greatly as has the automobile. The horse, man's great animal assistant since before the dawn of history, is being pushed into the background with a swiftness which would have seemed unbelievable. Streets that once echoed to the beat of hoofs are now noisy with the rasping blasts of automobile horns. Country roads on which, but a few years ago, the family buggy jogged comfortably along, are now hidden in clouds of dust from touring cars and runabouts. The draft horses which formerly strained to pull heavily-loaded trucks have been displaced by the motors that handle far heavier truck-loads without appeal to the sympathies of onlookers. Even the farm, last refuge of horsepower, is being invaded by tractors. Everywhere, the traditional stable is giving way to the garage.

The utility of motor cars, tractors and motorcycles has thus been established overwhelmingly, but the accompanying evils of motor accident and crime also have grown to such proportions as to force their way prominently into

the news columns of every day. Thus, inevitably, they have come up for study in the one institution that is best equipped for such investigation. Underwriters' Laboratories is constantly engaged in tests of safety factors in automobile design and construction, as well as of the locks by means of which the operations of thieves are resisted. These tests are of direct or indirect interest to everyone who intrusts his safety to a car or who pays premiums on automobile insurance. As is usual with the Laboratories' activities, this branch of the work grew out of the requirements of the insurance companies.

Automobile liability was first written in 1898. Originally, it was largely a matter of guesswork, but within twenty years automobile underwriting had become highly developed, had definite forms for fire, theft, collision, property damage and public liability, was being written by more than 400 insurance organizations and was paying approximately $100,000,000 a year on losses.

While moral hazard is perhaps the greatest factor, the importance of good design and construction, with safeguards against fire, theft and collision hazards, looms large, and in these respects the interests of insurance companies and of car owners are identical. Improvements in such matters are the natural result of coöperation among three bodies, namely the National Automobile Chamber of Commerce, the National Automobile Underwriters' Conference and Underwriters' Laboratories. As in the case

of other industries, this triumvirate was inevitable, and the way in which it came about is worth telling.

It began in a small way. Several auto-lock manufacturers, during 1915, applied for opinions as to the merits of their devices. When two or three of these devices had passed the tests and had been listed, the N. A. U. C., finding that theft losses were being reduced in consequence, decided to grant a premium reduction for the use of labeled locks. This established the first point of contact between automobile insurance underwriters as a body and the Laboratories. This work has grown so that now three engineers are constantly engaged in testing auto locks.

Next came the question of fire hazard. Fire insurance rates were at first based on horsepower, but the obvious difficulties of this method caused a change in rates based on list price—as everyone can remember. This, too, involved perplexing difficulties: for example, an automobile, which at that time was listed at $1,785, f. o. b. Detroit, took a greater fire insurance rate there than in Chicago where it sold for $1,805, the dividing line between rates being $1,799. The manufacturers, in consequence, proceeded to install a fifteen-dollar bumper as standard equipment on $1,785 cars sold in Detroit, changing the list price to $1,800 and causing a decrease in fire insurance rate *without increasing the fire protection.*

The automobile fire underwriters finally decided to follow the example of their colleagues in the general field

of fire insurance; they formally requested the Laboratories to ascertain whether it would be possible to develop a schedule wherein the inherent hazards of car and truck construction could be analyzed, so as to have rates based on such an analysis. After some meetings, the Laboratories undertook the large task of drawing up a schedule covering every inherent hazard, which meant hundreds of items, of determining the number of credit points or demerits for each item, and of *applying* this in a scientific and practical manner so as to grade American-made automobiles and trucks with regard to insurable hazards.

Manufacturers, as a body, through the N. A. C. C., approved the project—in principle. But what of individual manufacturers? Would the maker of a ten-thousand-dollar car take a chance on the Laboratories reporting that it should take a higher rate than that for a car costing one-twentieth which by luck might have been designed and was constructed in conformity with high standards from the standpoint of insurable hazard? As an even more perplexing question: would two—or ten—fiercely competing manufacturers of cars which were then taking the same rates on the price method, relish the necessity of standing in a row like schoolboys, metaphorically speaking, with this manufacturer at the head and that one at the foot—according to the points won by their respective cars, unless they might know in advance how the points of the schedule were to be won?

It must be repeated, that the Laboratories never solicits business, that its service is not compulsory, and that its only authority is that of scientifically determined facts. Therefore it could not urge manufacturers to submit their cars; nor could it urge any one to accept its findings. Furthermore, this work would be costly, and a number of manufacturers went on record as objecting to paying the Laboratories for examining their cars.

Strange to say, it was this objection which spelled the success of the whole undertaking: The N. A. U. C. finally instructed the Laboratories to examine all passenger cars at its own expense; this was late in 1920, and two years later the immense task was practically completed.

Its principal result was the publication of the Laboratories' Fire Schedule, and of two others, in which the design, construction and equipment factors affecting *collision* and *theft*, respectively, are tabulated and assigned various numbers of credit points in a scientific way. These schedules, as usual, were not published until passed upon by representative men outside of the Laboratories. In this field there was soon felt the need of a new council, and consequently the official Automobile Council was formed in 1919, with at first five members of the Rate and Statistical Committee of the N. A. U. C. and two members of the Laboratories' staff. Later, four more prominent automobile insurance men were added, making a total of eleven members.

In spite of the fact that the activities just referred to made possible a closer approach to scientific automobile underwriting than ever before, the schedules have not as yet received general application, save as to the fire schedule on passenger cars. While this fact has reduced the usual incentive of manufacturers in seeking tests and ratings, it has brought into sharp relief a still higher value. It is inspiring to find that this industry, whose output is daily entrusted with the lives of millions of people, has sought the aid of Underwriters' Laboratories in an effort to attain the highest degree of fire safety in its output quite apart from the question of insurance rates. *So far, more than one hundred and twenty-five cars and fifty trucks have been submitted, and in response to the suggestions made, about forty makes have been redesigned from radiator to tail-lamp.* Such a statement speaks for itself.

2. "Carding" for Fire Safety

"Only engineering features are considered in the Schedules," states the Laboratories' own preface. The *moral* hazard and the *fire exposure* hazard are not scientific entities; they are too elusive to reduce to laboratory terms, for the former arises out of human nature itself and the latter is governed by ever-changing conditions. It includes such questions as that of whether a car is kept in a public or private garage, the way in which the garage is heated and the many other combinations of physical

factors that affect thousands of individual cases. Therefore, while the insurance companies cannot by any means overlook these hazards, their study lies outside the scientific province of Underwriters' Laboratories and they are not considered in the schedules. Likewise, "questions of injury to persons or of damage to other property [than the car] are not pertinent". But with these excluded, there remains a large and important field for study in the engineering factors of fire safety. In the theft schedule, too, engineering factors alone are considered.

It would be out of the question to detail the many points that must be considered in judging the fire hazard of an automobile but there are four items that are deemed most fundamental.

The first of these items refers to the tubing and connectors between tank and carburetor. During the preliminary investigations, Laboratories' engineers were astonished to discover that the most elementary principles of fire protection were so often overlooked. And a study of fires showed that many were traceable to leaks which proper workmanship and the use of proper materials and methods would have avoided.

The second requirement is that the low tension wiring be of ample capacity for current load and mechanical strength. Here, as in many other features, manufacturers frankly admitted that the electrical fire hazard had never entered their minds; yet, an added expenditure of two or

three cents per car would in some cases have safeguarded this particular feature.

The third and fourth items refer to the connections and supports of wiring and to workmanlike joints and splices, with wires suitably supported at frequent points to avoid dropping, chafing, and excess vibration. Such points were elementary but were often overlooked, with the result that arcs and short circuits were of frequent occurrence and this in the presence of gasolene vapor! An inexcusable number of "total loss" fires have been due to the ignition of gasolene and oil drippings by means of imperceptible sparks that should never have been permitted to occur.

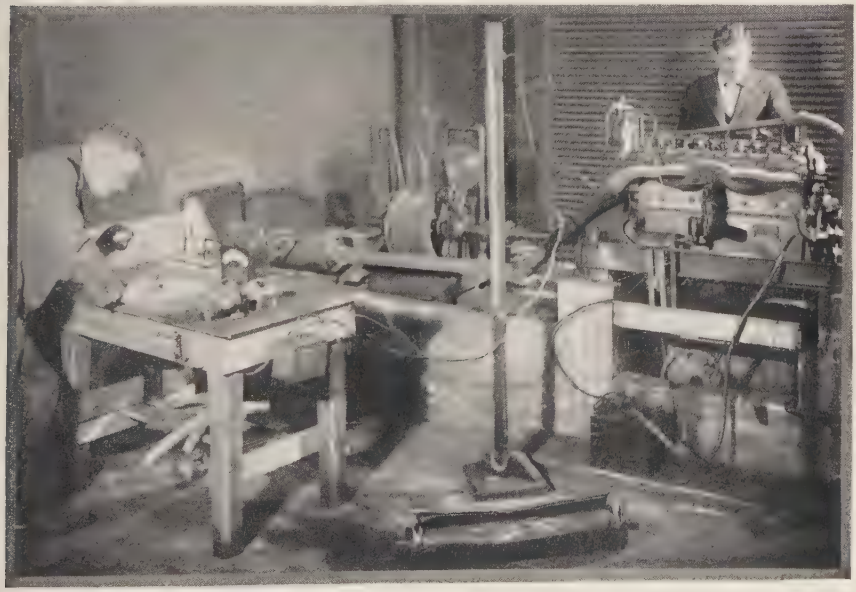
Vice-President Small said in an address before the Society of Automotive Engineers:

> As to the automobile fire hazard, from the viewpoint of design, it has seemed to me that the automobile industry has overlooked the fact that there is current in the storage battery. A storage battery can melt any piece of wire if there is a good short circuit.

Furthermore, what shall be said as to breather holes that exude oil, engine pans whose doubtful usefulness is outweighed by the hazard of their accumulated drippings, exhaust lines close under dripping carburetors, improperly vented tanks, feed lines below the road clearance, the simple but dangerous gravity feed system, tanks located in cowls and filled from under hoods, tanks that permit too large an accumulation of that hazardous fluid, gasolene, tanks that rattle, work loose and leak, tanks with

A WINDSHIELD VISOR ON THE "SHIMMY" TABLE

Will this visor hold its proper position during the vibration of travel on rough roads? The answer is here being given, for this table always "travels over rough roads"; in other words, it is mechanically vibrated to a degree that offers a severe test



A CORNER IN THE AUTOMOBILE ENGINE LABORATORY

Here is found a complete automobile power plant with absorption dynamometer for measuring the horse power developed. This is used in the heating and explosion tests of mufflers, operation tests of fuel feed systems, starting and ignition equipment, and other features. In the picture an automobile muffler at the right of the opening in the wall is being observed as to its radiation of heat. Sometimes, these mufflers are shoved through this opening and tested up to the point of explosion. At such times there is an alarming detonation. The muffler on the floor has been torn apart by an explosion

GUARDING AGAINST HEAD LAMP "GLARE"

Many devices have been submitted for the purpose of preventing the dangerous glare that has been responsible for so many automobile accidents. These are given scientific study at Underwriters' Laboratories. In the photograph, the light intensity of the head lamps in the background is being accurately measured by means of a photometer, the beam of light at any given point being studied in terms of apparent candle power

fill openings that are too small for curb pump nozzles, tanks that cannot be drained without removing them from the car, wires that run where oil and gasolene may accumulate, exhaust pipes that are close to combustibles and to the tank, feed lines without shutoff valves, and so on with various other hazards that would rarely occur to the user and might not occur even to a manufacturer if his attention were not specifically called to their presence.

However, the car owner is less interested in separate details of fire hazard than in their combined effect, for he is thinking of his car as a whole. How safe is it? That is what he wishes to know. Consequently, the Laboratories has now adopted a system of cards in which opinions are expressed as to specific makes and models.

A typical card bears the following statement:

> This automobile, of the model indicated, when equipped at the factory with any one of the body styles given below, has been found upon examination to be reasonably safeguarded against fire resulting from features of design, construction and/or assembly.

Complicated tests, weeks of time and a mass of technical information have been required, but in this case the results of them all have been summed up in just four words which any layman can understand—"reasonably safeguarded against fire."

It should be noted that no cars are "carded" unless the manufacturer has signed a contract providing for yearly reëxamination.

The foregoing applies to fire safety alone, and the collision and theft schedules are hardly less important.

The collision schedule deals with those mechanical features upon which a driver, often inexperienced, must depend when he sends the complicated mechanism under his control at high speed up hill and down, over ruts and tracks, past traffic, rocks and trees, and, in so doing, stakes his own life upon its performance.

Advertisements, when they leave off superlatives and come down to specific points, lay stress on such things as ease of control, flexibility, durability, strength, completeness of factory equipment and similar matters. Since these things have to do with the collision hazard, the Laboratories' engineers do not go by advertisements, but put cars through a searching series of examinations and practical tests upon all essential features. The most luxurious limousine cannot receive classification "A" unless it merits "full credit under Items 2, 6, 10, 14, 18, 24, 29, 31, 36, 38, 42 and 48." These include such exactly-defined requirements as: "hand brake grip released not over twenty-four inches from low point of steering wheel rim," "road clearance at least nine inches," "service brake area one square inch per 17.5 lb. car weight," to mention only three of these items.

The third schedule is that of classification with regard to theft hazard. It assigns certain credits to items of protection value, as is the case with the two preceding

schedules, and it deals especially with theft *retardants*, for, be it noted, there is no such thing as a "theft-proof" car. Given sufficient time, a mechanically expert thief can make away with any car. Theft retardants, therefore, are intended to make his profession dangerous by increasing the time required for his success.

The theft retardants recognized in the schedule are "standard listed and labeled locks built in stock equipment." These will be touched upon under the heading of "Automobile Appliances."

Another item, too often overlooked, is that of the identification of the car or truck by markings. Thieves generally know which makes and models have easily-changed numbers, and, other things being equal, they go after them rather than others.

This matter of identification, by the way, precisely because it leads to the recovery of cars, has an important bearing on the issue of moral hazard which the insurance companies themselves have made possible by insuring cars against theft. Thousands of car owners throughout the country, who may once have been proud of their cars, come in time to prefer the theft insurance money to the car itself. A number of "stolen" cars have been fished out of lakes, rivers and swamps, or have been discovered in quarries, usually with their identification numbers removed. Secretly-located numbers would have helped in tracing their erstwhile owners and the investigation of

all suspicious circumstances. That this moral hazard is not negligible is indicated by the significant fact that cars so often burn up in isolated spots, unwitnessed.

Prevention of over-insurance is difficult, and inherent protection, in the nature of identification marks, seems to offer the best promise of solution.

It is interesting to see the variety of marking devices which are submitted to the Laboratories and the ease with which most of them are defeated by the ingenuity of its engineers. These young men have expert knowledge of engraving, die-stamping, brazing, electro-plating and other necessary processes, but so also have many of the thieves; the thieves must be anticipated at their own game if real protection is ever to be evolved.

3. Automobile Appliances

The great majority of automobile appliances submitted for listing are locking devices. In this field there is intense competition, and yet we find listed locks costing perhaps over twenty dollars competing successfully with others selling for as little as two dollars. A large Chicago distributor for many automobile accessory manufacturers has declared that the Laboratories is the one stabilizing influence in the industry.

No one type of lock is *the* best type for all cars, and some makes and styles are designed for particular cars. This is not held as an objection by the Laboratories, which simply

prints these limitations under the name of the maker in the List of Inspected Automotive Appliances.

Three engineers are constantly at work on locking devices—which indicates both a crowded field and a complexity of problems. To illustrate these problems: a manufacturer had over $125,000 invested in jigs, tools and dies, and after studying the Laboratories' requirements with his own engineers, he concluded that he would have to scrap this equipment in order to comply with them. The Laboratories' engineers worked out changes which allowed him to continue to use most of it. He later thanked them for saving him over $100,000.

Three samples of each locking device must accompany the application for listing. The first is thoroughly dismantled and investigated, and the other two are then subjected to "expert premeditated attacks" by methods determined from the study of the first one. When deemed necessary, another sample is subjected to a seventy-two-hour test on the vibration table, familiarly known to the staff as the "shimmy table". This test is made for the purpose of showing whether the sample will be locked by the shaking process of a rough trip and is the full equivalent of traveling thousands of miles over rough roads. Corrosion tests are also made, and, where electricity is involved, the maximum rated load is applied throughout the operation and other tests.

The engineers in charge of this work have acquired

marvelous skill, and are fond of telling the story of the enthusiastic manufacturer who breezed in with the statement that the theft problem was solved once for all, thanks to his lock. The engineer on whom he was calling learned that he had driven up in his own car, and deduced that it was equipped with one of his locks. The engineer winked at an assistant who thereupon went to the manufacturer's car, easily defeated the lock and then drove the car out of sight around the corner. A few minutes later, the manufacturer suggested that the engineer go downstairs to have a look at the car, with its "theft-proof" locking system, and his consternation on reaching the spot where his car had stood so short a time before may be imagined.

Here is the procedure in a typical "driving test": A steering wheel lock comes in for investigation; it chances to be a combination lock of the "free spinning" type. In other words, when locked, the wheel can be spun without moving the steering rod. Surely, no thief will run away with a car that cannot be steered—so says the inventor.

The testing engineer takes the car out on the lake front where traffic is light and proceeds to do the things that he believes would occur to the mind of a skilful thief. He does not try to unlock the device—in fact, he does not even know the combination—he merely tries the obvious method of getting a friction bearing on the rod by means of pressure. The car whizzes down the road and comes to a cross street. The engineer presses hard on the wheel

in his hand and turns the corner with little difficulty. At the next corner the wooden rim pulls loose, but it appears that the car still can be steered by means of the struts.

Next, he unfastens a screw and easily lifts the wheel from its position. This exposes the end of the steering rod and with this gripped tightly in a pair of pliers, he directs the car without trouble. There will be another disappointed manufacturer when the report is made, but better so than that car owners should put their trust in a lock that does not furnish protection.

In typical tests of a different kind, the engineer confronts a key lock which lifts the gearing of the steering wheel out of mesh and thus prevents its operation. The engineer picks up a hammer and strikes a few quick blows which drive the rod into position. In exactly ten seconds the lock is defeated and the "thief" can run off with the car.

However, the tests go still further in order to aid the manufacturer by furnishing him with reports of all the defects which it is necessary to overcome. In the next instance, the lock is unfastened by taking out a set-screw and driving out the locking pin; time: three seconds.

Following this, a hack-saw is called into play and the housing is cut in order to remove the pin. The lock is opened in one minute fifty seconds. A final test of similar length requires cutting into the locking cylinder housing, knocking out the housing and then operating with a screw-driver in order to get the bolt into driving position.

These tests involve but two of the many kinds of locks and none of them calls for more than a few simple tools such as any automobile thief may carry with him. It is perhaps small wonder that car-stealing is so grave a menace.

Bumpers run locks a close second in point of number, fifty-two makes of front bumpers alone being listed. The tests are not gentle. Imagine the jar of driving a 2,500-pound car full tilt into a stone pier at four miles an hour! Would the bumper protect its occupants? In order to satisfy the Laboratories' requirements this condition must be met. But how? Shall an expensive car be imperiled by sending it against an obstacle in trying out an inexpensive bumper? By no means, for a simple device of great ingenuity fully serves the purpose, and the tests that it permits are somewhat spectacular.

The bumper under investigation is fastened, not to a car, but to the front of a strong automobile frame which, in turn, is bolted upon a concrete block. Hanging from a beam seventy feet overhead, like a giant pendulum, is a 650-pound weight. This weight is drawn back to a given distance, not exceeding twenty-three feet, and then released. Forward it swings in a wide arc, gathering speed as it goes, and delivers a violent blow upon the bumper, which bends before it and then, if it be of sufficient strength, springs back into shape. The theoretical "car" has been saved. Other swings may come at other dis-

WILL THE BUMPER PROTECT YOUR CAR?

Something more than manufacturers' claims are necessary to answering this important question. Some bumpers are stiff and non-resilient, others bend and break under impact. There is no need to wait for an accident, for here is a bumper mounted in a chassis frame receiving a blow from a swinging pendulum of 600 pounds

WHY AUTOMOBILES ARE STOLEN

Myriad forms of locking devices are offered to America's 10,000,000 car owners. Some of them are excellent, others are defeated with ridiculous ease in a few seconds by means of such tools as a thief might carry in his pocket. It may be assumed that the steering wheel lock in the picture will not receive the coveted label if the testing engineer is able quickly to force its housing by means of a hammer and cold chisel

A LOCKING CYLINDER AFTER 100,000 OPERATIONS

Automobile locks, in addition to being "pick proof" when new, must remain effective after long use. By means of the patient and persistent machine seen in the photograph, a key is inserted, turned, and withdrawn 100,000 times in succession. This must not produce appreciable wear in the locking cylinder or decrease its theft protection

tances and from other angles, and in each case the conditions and facts are carefully noted.

Several years ago the yard contained quite a pile of shattered bumpers, representing the shattered hopes of manufacturers, but their destruction has made for improvements which have greatly raised the level of this useful device. Of course, the bumping test is but a part of the investigations, which cover the usual subjects of practicability of installation and use, durability, the protection afforded to exposed parts of the automobile front, and other items.

One interesting series of tests has made use of the spectroscope in judging of wind-shield visors. This type of appliance is intended to protect the driver from the glare of the sun or of approaching headlights, hence it makes use of colored or clouded glass designed to absorb certain of the rays and allow others to pass. There is an obvious peril if the glass fails to show the red light of danger signals and its characteristics in this respect are tested by means of spectroscopic photographs.

These are but a few of the subjects of study, for the field of automobile appliances is an attractive one for inventors, and the number of submitted devices is fast growing. The Laboratories is frequently in receipt of applications which have to be rejected because they bear no distinct relation to recognized hazards, notwithstanding which the List already includes more than a thousand

items, covering fire hazard, collision hazard and the hazard of theft in myriad ways.

For all these reasons the safety of millions of car owners is vitally affected by the constant investigations that are made by the engineers of the Automobile Department.

CHAPTER SEVENTEEN

Certifying Aircraft and Pilots

1. The Newest Department

IT WAS not until ten years after the beginning of Underwriters' Laboratories that aviation emerged from the realm of "moonshine" and became a subject for men to take seriously, for it was in 1903 that Wilbur and Orville Wright made their first success in a very primitive kind of airplane flying. Prior to this time man had made himself mechanical devices which enabled him to outrun the horse and outswim the fish, but the art of flying, in which birds and insects were so adept, had seemed impossible to acquire, the clumsy and dangerous sport of ballooning having no claim to be considered flying, and even the remarkable experiments of Langley suggesting little of immediate value.

The Wright Brothers came at last, and, through them and others, aviation was placed on a solid foundation, if such a mixed metaphor may be allowed. Today, the hum of the airplane propeller has become too familiar to arouse special interest. Airplanes are traveling through the sky every minute of every day, and frequently at

night; mail planes make trips on schedule time and definite passenger service now exists between various points.

The number of private owners of airplanes is rapidly increasing, and many of the insurance companies have begun to write coverage in response to demand. In consequence, there have arisen the usual questions: "What are the hazards? How can they be minimized? What should insurance cost?"

It was natural that the National Aircraft Underwriters' Association should have turned to the Laboratories in order to find the bases for the answers.

The Laboratories undertook this important work in 1920. It began in its usual way, by assembling and arranging known facts, by engaging the best obtainable talent to ascertain facts yet unknown, by evolving definitions and classifications, by studying existing standards, and by formulating requirements to minimize hazard.

A former army aviator, then holder of the world's altitude record of over seven and a quarter miles, was engaged as the Laboratories' aviation engineer. Following this, coöperation was obtained from engineering societies, aero clubs, the War, Navy and Post Office Departments of the Federal Government, the Air Board of Canada, manufacturers, pilots, owners and other sources, in addition to the insurance interests. A competent staff was developed, and this included picked resident engineers at aviation centers throughout the country. It was decided to follow

that "charter of international flying," the convention of 1919, which was one of the results of the Peace Conference, and established a broad basis for uniformity of control of air traffic.

The investigation problems divided themselves into two principal groups: those of the *craft* and the *pilot*, with a third concerning supplementary factors, like landing fields, water areas and hangars. An early question involved the craft owned and operated by the federal government. This led to a broad classification of aircraft, into "government" (those used for military, post office, customs, post guard or police duty), "commercial" (those used for the purpose of any profession, trade or business), and "private" (including all aircraft not listed as "government" or "commercial").

The next steps were to register individual planes and to create a register, on the lines of Lloyd's register of commercial and private vessels. However, all this was merely preliminary, for, on May 1, 1922, the Laboratories began the operation of a nation-wide inspection service, in order to make it possible to issue "certificates of air-worthiness" for individual aircraft. With regard to pilots, the Laboratories followed the nautical example. It undertook the registration of pilots other than "state," together with their individual rating, based on periodical examinations and tests. These two subjects, aircraft and pilots, can best be understood in a separate discussion.

2. Planes, Parts and Accessories

The development of the airplane and seaplane from the time of the great international competition at Rheims in 1909 has been both romantic and irregular. Flyers would advance the art; then builders and engine makers would make their contribution, and the difficult science of aerodynamics would be applied in the improvement of lines and wing shapes; next inventors would devise better controls, landing gears and other necessities; and once more daring flyers would overcome "air pockets," would discover how to get out of a tail spin, would remain in the air longer and longer, and would add new stunts to the art of "aerobatics". Speeds have risen until racing planes are able to travel faster than did cannon balls at the time of the Civil War; the altitude record has reached 40,000 feet, and the Atlantic Ocean has been taken at a single bound; lateral and longitudinal stability have been realized; over a dozen passengers are carried in Pullman comfort and night flying is a commonplace. As to safety, the number of miles flown *per accident* is one-and-a-half times around the earth, and the United States Postal Service planes flew more than 1,700,000 miles in a year without the loss of a single life. "I would rather ride in an airplane any time," declared Major Schroeder, "than to cross Fifth Avenue afoot, or stand near the east end of a westbound mule." In support of this comparison he called attention

to the fact that out of thirty-eight airmen who were killed in a year, thirty lost their lives through "stunt flying," while eight persons were said to have been killed by mule kick during the same year.

Outside of taking unnecessary chances, the greatest cause of aviation accidents is that of unforeseen and uncontrollable conditions, such as the arch enemy of aviation —fog. Nevertheless there are accidents due to faults in design and construction, workmanship and maintenance, which are being discovered little by little. These are engineering factors and come within the natural field of the Laboratories, which performs two distinct services, under the headings of Registration and Certification.

Registration does mean more than the mere assigning of a serial number in conformity with the International Convention system, though this is the best-known part of it, and the familiar letters are visible from considerable distances; the applicant must also furnish general information and details which have an important bearing on many phases of insurance. Some of these items appear in the registration certificate reproduced on page 257.

Certification of Airworthiness, on the other hand, is based on a thorough inspection and flight test of the machine itself. A few words of explanation are here necessary:

The two principal recognized hazards in this connection are collision and fire.

Perhaps the most serious cause of fire accidents is the back-fire, which most frequently occurs in descent, when the pilot shuts off the engine in order to volplane down to the landing field. When several hundred feet above the ground, the pilot opens the throttle, there may be a back-fire because of the cold engine and this may ignite the accumulation of gasolene and oil drippings.

Other fires are caused by faulty design in electrical equipment and gasolene system, as in the case of automobiles, but with the difference that a plane may assume positions that will cause gasolene and oil to drip—as some people who have flown in their "good clothes" are likely to recall.

This also is true with regard to crashes and other accidents from "loss of control". The aircraft itself—fuselage, wings, ailerons and rudders—has been brought to a high state of development; and so has the internal combustion engine; but many other things are needed: a cooling system, a fuel supply system, a carburetor, an ignition system, a lubrication system, a number of instruments and an intricate set of controls. Therein lie the principal hazards, and Underwriters' Laboratories is already taking important steps in this direction.

All of the hazard factors, and the safety elements of that complicated mechanism, the modern airplane, are investigated with the usual thoroughness of the engineers who will take nothing for granted and who reach their conclu-

RATED SAFE LOAD 900 LB.

Underwriters' Laboratories
INCORPORATED 1901
ESTABLISHED AND MAINTAINED BY THE
National Board of Fire Underwriters
FOR SERVICE - NOT PROFIT
207 EAST OHIO STREET, CHICAGO

MAXIMUM NUMBER OF PASSENGERS INCLUDING CREW 5

AIRWORTHINESS CERTIFICATE

Issued to VINCENT ASTOR Address 23 W. 26th ST. N.Y.City.

This Certifies that the *Aircraft* described below has been inspected and found *Airworthy* for daylight flying on AND OVER WATER ONLY

For the Flying Season of 1922 Void thereafter

This certificate is automatically cancelled following a crash involving structural damage pending inspection

Certificate No. 3

UNDERWRITERS' LABORATORIES, Inc.

Date of Issue JULY 31, 1922. By A. R. Small Vice President

DESCRIPTION OF REGISTERED AIRCRAFT

Nationality and Registration Mark N-ABCU as a PRIVATE WATER AIRCRAFT

Having usual stations at PORT WASHINGTON, L. I. N.Y.

Number of Persons to be carried 5 Maximum Pay Load Allowed, including Crew 900 lb.

Manufacturer LOENING AERO. ENGR. CORP. Maker's Type No. 23-L Serial No. 2

Over all length 30 FT. 3 IN. Feet. Span 42 FT. 6 IN. Feet. Height over all 8 FT. Feet

Dead Load 2700 lb. Full Load 4100 lb. Useful Load 1400 lb.

Air Speed 130 M. P. H. Service Ceiling 20,000 Feet. Radius Full Throttle Hr. 3

Engines: Type LIBERTY IL Number of ONE Registry Nos. U.S. 32230

Maximum Aerodrome Elevation 5,000 Feet. Inspected by MAJ.J.W.JONES Date JULY 7, 1922.

Underwriters' Laboratories' Airworthiness Certificate No. 3, issued to Mr. Vincent Astor, is the first airworthiness certificate to be released for a privately owned and operated seaplane.

sions after considering hundreds of separate items in twenty-seven different groups.

Such investigation is followed by the flight test itself and this is the point where theory is checked against actual performance, for the plane is sent up to prove its proficiency in the sky. Now the machine is taken into the field, loaded up to its full rated capacity; the engine is warmed up, the propeller begins to whir, and soon the artificial bird is a diminishing spot against the sky. In

technical jargon, the plane has a rated service "ceiling," which means the measure of the height at which the "rate of climb" diminishes to one hundred feet per minute. The test climb is one against time, to about one-third of this distance, with various kinds of observations being taken at every 1,000 feet; then the plane is brought down to a height of 1,000 feet above the ground and flown "full out" for ten minutes, with many observations being taken.

It is because this entire work is in process of development that the Certificate of Airworthiness is not based on inflexible requirements, except in so far as certain items and principles have been formulated in standards and recognized by official bodies. One of these is the National Safety Council, of which the sub-committee on planes and engines is headed by an officer of the Laboratories.

Completely assembled airplanes are classified by the Laboratories according to type, design, equipment, ability in operation and facilities and practices of manufacturer. For several years, production will not warrant the replacement of certificates by labels, but this development is bound to come. As a matter of fact, the operation of the inspection system leading to the issuance of Airworthiness Certificates is along the lines of the Laboratories' work on many other products, though the "label" is issued to the owner instead of to the manufacturer, and is not affixed at the factory, but at some aviation center where the Laboratories is represented by a resident aviation engineer—

always an expert of high standing. This engineer issues only a Temporary Certificate of Airworthiness. The final certificate is later sent from Chicago after the data have been carefully analyzed, checked up and compared with other information there on file.

Materials and Devices. As in the case of the automobile industry, the use of materials, accessories, fittings, etc., which have been listed by the Laboratories after appropriate examinations and tests is of great usefulness. This work was begun simultaneously with that on assembled aircraft, and has so progressed that it is contemplated to issue a special List of these many materials and appliances before 1924.

To illustrate the practical application of the Laboratories' work in aeronautics: a famous aviator attempted a much-advertised long-distance flight in the summer of 1922, but fell and wrecked his plane at a midway point. His own skill was beyond question, but it happened that his machine had been inspected prior to the flight by engineers of the Laboratories, who found it mechanically sub-standard, advised him not to use it in the intended flight and wired their conclusions to the insurance company to which application had been made for a policy; in fact, the plane in question was definitely refused registration by the Laboratories.

3. *Pilots*

What the soul is to the body, so is the pilot to the airplane. The machine is an extension of the man, re-

sponsive to his slightest motions. The art of flight, therefore, requires first of all the ability to control and coördinate the movements of hands and feet; the novice must think out these movements, but with the expert pilot they become so instinctive that he has but to *wish* his airplane to perform an evolution for it to occur. To know *what* to wish, the pilot must rely upon his senses, which must be acute at all times, even after a long and fatiguing flight. This requires the kind of endurance that comes only with excellent lungs and heart action and good abdominal tone. An aviator must have quick perception and judgment in order to be able to meet sudden emergencies. The strain of flying and the effect of high altitude tell on the nervous system in particular. During the war, some of the most athletic pilots, who easily passed purely physical tests, quickly broke down, even in home service.

To classify and label men—this, in effect, was the request of the National Aircraft Underwriters' Association in proposing that the Laboratories become custodian of the official Register of Aircraft Pilots (other than government pilots) and take full charge of all details connected therewith. And when Association members pledged themselves to recognize the Laboratories' certificates as a condition of their policies and the various aero clubs and other official bodies approved the idea, the Laboratories undertook this branch of the work on July 1, 1921.

Fortunately, there were plenty of data on the subject. Likewise, there were thousands of trained pilots throughout the country, for at the time of the Armistice there were 7,118 qualified flying officers in the United States and 4,307 overseas. It naturally was decided that former Army and Navy flyers were entitled to registration, provided that they complied with certain conditions, the most important of which was to have flown *recently*, and also that they be in good condition physically and mentally at the time of their application. But new candidates are constantly appearing, men without war experience, and these men also required to be tested and approved.

There are schools which claim to educate students to become airplane pilots, but do not have any preliminary requirements as to the applicant's fitness to receive instruction. The diploma of such schools is not a sufficient safeguard. Underwriters' Laboratories occasionally is compelled to refuse certificates to applicants who have been "passed" by schools of this type.

A successful pilot is both "born" and "made." There are many things for him to learn before he can be permitted to carry trusting passengers through the upper levels, and his instruction must be thorough and practical; but the starting point—the man himself—is the most important factor. It is only the exceptional man who has the capacity for acquiring the art—the man of clear head, quick eye, keen perceptions, natural resourcefulness and

lightning-like coördination. Ingenious and practical tests to determine these faculties were worked out and employed by government authorities during the war and their methods are followed by Underwriters' Laboratories.

The medical and surgical examination of new applicants is required to be strict, and examining physicians are reminded that applicants will be "responsible in an exceptional degree for the safety of life and property of others."

Eyesight is the most important of the senses for pilots. All birds have keen sight and can readily estimate distances. Birdmen are helpless without good eyes. There was one pilot whose only failing was that he could not land smoothly; it was discovered that he had an artificial right eye which made it difficult for him to judge distance from the ground. Slight visual defects may prove fatal.

Almost as important is acuteness of perception of sensation from the skin and muscles. The experienced pilot flies by the "feel" of his machine, of his controls, of his seat and of the wind on his face.

The pilot's hearing must be good and susceptible of training, because he is constantly listening to the singing of the wind in the wires, to the sound of the engine, the roar of the exhaust and the hum of the propeller. He also may be required to use a telephone or to operate a wireless.

Swiftness of reaction is essential, and various tests have been designed, such as that of *simultaneously* maintaining the pitch of hum of a motor by a foot control despite the

efforts of someone else to alter it, maintaining the pointer of an ammeter at a given point by means of a rheostat worked by the left hand and touching with the right hand the proper button controlling one of a number of lamps which are successively and unexpectedly lighted. During such tests, the applicant is at first allowed to breathe normally, and then his nostrils are closed and he is made to breathe through a mouthpiece from a "re-breather" tank, by means of which, as the oxygen becomes exhausted, there are reproduced some of the difficulties of breathing at high altitudes. In this way candidates are sometimes taken to "altitudes" of 30,000 feet or even higher. It is always noticed that the candidate's senses become sluggish and his motions unconsciously grow slower, as the proportion of oxygen grows less.

Registration of pilots expires after one year, but may expire earlier if more than ninety days elapse without flying. "It may be cancelled or suspended at any time for cause and is automatically suspended following a crash involving insurance loss pending inquiry."

* * *

Thus the day has arrived when "Darius Green and his flying machine" are no longer a standing joke, for the traveler may now navigate the air with as much assurance as he may ride upon the seven seas. Indeed, the procedure is much the same, for he now is able to purchase a

registered aircraft, to have its condition inspected and certified by an adequate authority, to have it flown by a *registered* pilot whose rating has been certified for the season, and to protect his property by an insurance policy.

In all these respects, Underwriters' Laboratories is effectually aiding an art and an industry, yet in their infancy, but with promise of an immeasurable future.

CHAPTER EIGHTEEN

Underwriters' Laboratories and Human Welfare

IN THE foregoing pages an attempt has been made to set forth the origin and work of a dynamic institution whose activities reach beyond its industrial contacts and affect the safety of millions of people. Born out of necessity it has grown without promotion and in an inevitable sort of way that proves how essential it has become to human welfare.

The industrial contacts of Underwriters' Laboratories are naturally the more immediate and in these its relations are decidedly unique. It is an unofficial body; it is backed by no legislation, yet it has become almost an integral part of many industries. This is shown by the following figures giving the number of appliances which have been examined and tested and are covered by the *current lists:*

Electrical goods	5,465
Building materials	1,585
Fire-fighting equipment	793
Devices related to hazardous substances	2,410
Burglary protection systems	67
Automobiles and automotive goods	680
Miscellaneous	309

To these may be added thousands of earlier types tested in preceding years.

In many of these fields its operations are large, as appears in the growth of its label service from fifty million in 1915 to more than five hundred million in 1922. Yet the Laboratories has no commercial motive, makes no profits and maintains no sales department. All its relations are voluntary. The fact that so large a number of manufacturers are seeking its services is due to the quality of the services themselves.

This statement is the keynote of the institution. A visitor is struck with the absolutely impersonal nature of the work. Manufacturers do not exist as individuals while their products are under scrutiny. All are met on the same basis. No one is favored; no one is slighted. The work is not to be unduly hurried no matter how impatient a producer may be. It goes forward with steady, intent thoroughness until every essential fact has been determined and recorded. Then, and then only, is the rating given and the label awarded.

As a result, the labels of Underwriters' Laboratories *mean something.* They are recognized as incontrovertible evidence that the goods which bear them really possess the qualities of their rating. This explains why the service has been sought so extensively in the industrial world.

Some indication has already been given of the manner in which the Laboratories operates. It has been shown

that its activities originally were inspired by the need of insurance companies for exact knowledge as to many of the elements of hazard that must be taken into account in underwriting. This need has led to the fixing of various standards of safety concerning the thousands of products that are related to fire prevention and fire protection and, more recently, to casualty prevention, burglary prevention and automotive and aeronautical safety.

Such action has been a matter of the largest financial necessity. The total volume of insurance in force in these fields exceeds one hundred billion dollars—an unthinkable sum, yet one that is represented by many millions of separate business contracts. This insurance must be based on an understanding of risks, otherwise underwriting would be a mere gambling venture, short-lived and unreliable rather than the great foundation of credit and supporter of all prosperity that it is today. But risks cannot be guessed at; they include many physical elements which require scientific determination since they are at the heart of the underwriting process.

This insistent need has resulted in the creation of Underwriters' Laboratories and caused its growth into field after field. No bias could be allowed to color its judgments. Hence the motive of profit was rigidly excluded and the charges of the institution were put upon the basis of the expenses of each test, plus a pro-rata share of overhead.

Similarly, there must be no ground for challenging its

findings as to thoroughness and accuracy. This situation was met, as has already been told, by assembling a staff of highly qualified technical experts equipped with testing facilities so extensive as to be a revelation to the uninitiated. The system of inspection conducted in thousands of individual factories has supplemented the laboratory tests and the labels of the Laboratories have certified its ratings to the general public as well as to the insurance companies. These latter, thereupon, have made them the basis for the assumption of enormous financial obligations. They have backed the findings of the Laboratories on an almost incredible scale.

Thus has come about a strange yet logical paradox—the operations of an entirely non-commercial institution in behalf of a great business interest.

It is significant that these operations have assumed a definitely public service character; and herein is another paradox, that of *the altruistic effect of a selfish motive.* It is not denied that the insurance companies have a direct financial stake since they must determine the exact elements of hazard upon which equitable premium rates are to be based—a matter of concern to the public as well as to the companies. This is a natural motive; indeed had there not been such a motive the work of the Laboratories would have been short lived.

It chances, furthermore, that the study of hazard involves that of safety—the two are inseparable—and that

the safety thus considered is that of the public, whose welfare and that of the companies thereby become identical. It is easy, therefore, to picture the individual engineer at his testing apparatus; forgetful of producer, dealer, purchaser or insurer, forgetful of everything except the particular article under test, and, behind him, the thousands of towns and the millions of homes and individuals whose security is being conserved by every step that is taken, the insurance organizations whose resources are at stake, the manufacturing plant whose product is being scrutinized and, finally, the great army of operatives, salesmen and dealers whose activities are thereby affected.

In carrying out this work, Underwriters' Laboratories naturally has come into close relations with many organizations and individuals, among which are:

The Director of the United States Bureau of Standards, the Director of the United States Bureau of Mines, committeemen designated by the American Society for Testing Materials, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Society of Automotive Engineers, the National Fire Protection Association which is composed of more than a hundred societies and official bureaus, the National Automobile Underwriters' Conference, the National Board of Fire Underwriters and its many bureaus and sub-divisions, the Fire Marshals' Association of North America, the International Association of Fire Engineers, the National

Safety Council, the American Society of Safety Engineers, the American Institute of Architects, the Associated Manufacturers of Electrical Supplies, the Manufacturers' Council, the National Association of Manufacturers, the Chamber of Commerce of the United States, the City Managers' Association, the National Gas Engine Association, the Canadian Electric Railway Association, the Fire Extinguisher Exchange, the Rubber Association of America, the American Engineering Standards Committee, the Department of Commerce of the United States, many other federal, state and municipal governmental bureaus and departments, many commissions appointed by governors and mayors, and a number of industrial bodies such as the Electrical Manufacturers' Council, the National Lumber Manufacturers' Association, the Hollow Tile Association, the National Automatic Sprinkler Association, the Safe and Vault Manufacturers' Association, the American Concrete Institute, the Portland Cement Association, the National Association of Steel Furniture Manufacturers and the Associated Metal Lath Manufacturers.

These relations involve coöperation; sometimes in promulgating safety standards, as with the National Fire Protection Association; sometimes in applying the findings to towns or to buildings, as with the engineering committees of the National Board of Fire Underwriters and many local underwriting organizations; sometimes in

reviewing the reports of tests, and the ratings resulting therefrom, as with the industrial and professional advisory committees already discussed, and, occasionally, in the investigation of fundamental scientific laws, as with certain of the professional associations and societies.

Brief successive glimpses have now been taken of the work of the different departments, although each in itself might furnish material for volumes, and the merest suggestion has been offered as to ways in which these departments severally affect the industries whose products they examine. But truest impressions are gained when Underwriters' Laboratories is viewed not as an assemblage of units but as a complete institution—compact and homogeneous. This, in truth, it is, for it came into being from one cause, operates along standardized lines and exerts its influence to one general end. In this unified sense the influence of the institution already has become incalculable and has made its way into all of the industries affected.

Instances of misunderstanding have been many. Cases of opposition have not been wanting. In not a few cases, manufacturers or groups of manufacturers have shown at first a perfectly natural resentment that an outside organization should appear to dictate standards that they would be required to follow if their products were to enjoy sales opportunities in many fields. It has been the subject of heated discussion in meetings and in the

editorial columns of trade publications, but all this has, in the long run, proved of advantage, in that it has served to fix attention on facts that needed only to be understood to be approved.

Following such resistance, the industries in question have grown gradually into a better appreciation of the Laboratories' work. They have come to see that it assumes no authority but that which is inherent in the facts with which it deals. Its rating of a product neither endows that product with qualities nor deprives it of any, but merely *ascertains and registers those qualities which are given it by its own manufacturer.* Just as the diploma of a university is not a gift from the president but a token of achievement on the part of the student, so the labeled product has an inherent right to its label; the product wins this right and the Laboratories determines and certifies—that is the essential distinction.

It follows that wherever a producer is willing to comply with certain minimum and entirely reasonable standards there is no question as to his receiving the evidence of recognition as soon as his compliance has been made manifest. It also follows that any opposition to the tests is sometimes regarded by outsiders as indicating his distrust of his own product.

Furthermore, since the tests of Underwriters' Laboratories have a bearing on the question of human safety, such a manufacturer may find himself in the difficult

position of appearing unwilling to comply with necessary standards of safety while offering to the public goods that may be unworthy of complete trust. This, of course, is sometimes the case. Sub-standard goods can be made and sold below the prices of honest products, and the better grade of manufacturers are coming more and more to realize that the certificate of quality (in relation to safety) implied in each label is a protection to the industry as well as to the public. So well is this now appreciated that, if the underwriters were to lose their interest in the work of the Laboratories, many manufacturers would still wish its continuance as a matter of industrial health, as a tonic to their production departments, as an incentive to maintenance of high standards and as a counter-check on their own inspectors.

The relation of the institution to retailers, contractors and officials already has been indicated, but there are two lines of special influence that deserve a word of discussion.

The first of these is its potential effect on the architectural profession. As is well known, America's per capita fire loss is many times that of Europe. This is due in part to the higher average of carelessness in this country and to the greater employment of hazardous devices and materials, but it also is largely due to the greater combustibility of building construction in the United States. Making all due allowance for the inevitable employment of frame construction it still is true that the many ways

in which combustibility can be reduced are worthy of the largest attention on the part of architects.

Architecture is one of the fine arts in its esthetic appeal and many architects are so intent upon the beauty and convenience of their designs as to underestimate the fire hazard sometimes inherent in their finest effects. While some leaders of the profession are whole-hearted advocates of fire-safe construction, it still is true that many of the rank and file are not yet aroused to a consciousness of its importance. In a sense, the architects of America are responsible for its buildings—even for that large percentage in which an architect was not employed, since the natural leadership in the field is theirs. If every architect should familiarize himself with the results of the investigations made by Underwriters' Laboratories as to structural materials, fire-fighting equipment, electrical materials and other related subjects, it could not fail to exert an important influence on the safety of American communities.

Another field of influence is that of scientific and technical education. Most institutions of higher learning are equipped for laboratory work of various kinds but these, in the past, have devoted far more attention to abstract than to applied science. The practical *application* of scientific knowledge to problems of public safety found in the investigations of Underwriters' Laboratories is suggestive of a large field of indirect helpfulness to schools and colleges. An admirable example of this relationship al-

ready exists with regard to some classes of the Armour Institute of Technology.

Furthermore, the comparatively new profession of fire-prevention engineering is now engaging the attention of an increasing number of students. Conservation of all kinds is so importantly related to national prosperity that everything tending to reduce hazard and diminish loss enjoys a status almost unknown a generation ago.

The promotion of conservation is becoming more and more a professional matter in that it involves the formulation of methods that have approved themselves in practice, and among all the branches of conservation, few have reached a stage of development comparable to that of fire prevention. It has already come about that fire-prevention engineers, as such, are employed in industrial and public service concerns as well as by underwriting organizations; and the day may not be far distant when fire-prevention engineers will be attached to all leading architects' offices. Underwriters' Laboratories already has graduated members of its staff into outside positions of responsibility, and its studies are contributing materially to the development of this new profession. However, the influence of the Laboratories in underwriting, industrial, architectural, commercial, educational and engineering fields is, after all, collateral to its most important function which is that of increasing the safety of the public.

People live in houses; these houses may be covered with

combustible or with fire-resistive roofings; they may be equipped with safeguarded or with hazardous lighting and heating installations; they may be constructed of materials and in a manner to protect the lives of the occupants or to invite disaster. People, millions of them, are employed in factories where they come in contact with countless industrial processes that may be made either dangerous or harmless. People ride in automobiles. People are preyed upon by the tens of thousands of cracksmen who infest the country and, in defense, place their reliance in locks and alarms. People, in short, during almost every hour of their lives, consciously or unconsciously are involved in some of the hundreds of safety problems for whose solution Underwriters' Laboratories exists and whose magnitude is implied in its issue of more than 500,000,000 labels in a single year. In spite of the multiplicity of disasters that seem to be the product of our crowded modern life, no unprejudiced student can escape the conclusion that life and property in America are, even now, far safer than would have been the case had not this institution devoted its powers upon so large a scale to *the reduction of human hazard.*

Even now, this effect is appreciable but, in a peculiar degree, the work which produces it is related to the future rather than to the present or the past. Civilization is not static; the processes of change were never so swift nor diverse. Material conditions no longer are reckoned in

centuries or even in decades—they are transformed in years. Everywhere applied science is opening new vistas of production, transportation and communication; everywhere man is being supplied with new resources and, as a natural corollary, is being menaced by new perils.

With humanity ceaselessly discarding its past and plunging forward into the uncertainties of its future, it is reassuring to note the steady progress of an organization whose protective influence entitles it to be regarded as *a symbol of safety*.

THE END

APPENDIX I

Details About Labels

Of the thousands of different labels issued by the Laboratories, the least costly are those for hundred-foot lengths of flexible cord, fixture wire, etc., which come at one-half cent. The other extreme is the label for stationary fire extinguishers, the price of which is $7.50. But except in rare cases, and then only because of limited production, the cost of the label is *less than one per cent. of the product's price.*

Labels come in a great variety of sizes, shapes and colors; and metals, cloth, paper and other materials are used, as well as the decalcomania process, which is growing in popularity among subscribers. The most decorative labels, taken as a group, are those for automobile locks: they are combination labels, including the manufacturer's name and address, and other data together with the usual Laboratories' wording and number, and are of etched aluminum in the form of rings, stars and other artistic shapes. A manufacturer of electric service entrance cabinets which have wiring diagrams pasted inside the cover combined the label with these and their checking is successfully done through the printer. A similar arrangement was agreed to in the case of a roofing manufacturer, the label being made a part of the wrapper. As to matches, everyone knows that the Laboratories' label is included in the paper covering of the box.

Some labels include a brief paragraph cautioning the user as to the handling of the appliances, as in the case of moving picture machines, tanks and other devices for hazardous fluids, flame-proofed cotton bales, etc. Labels used for wire, conduit, tubing and other goods sold by the length come in various denominations, such as one hundred feet, one thousand feet, and intermediate denominations. A similar system is used in the case of fire extinguishers and other devices which come in various sizes, and in electric signs—this label coming in twelve denominations according to the number of lamps. The proper location for certain devices is mentioned on their labels, as in the case of fire doors or shutters "for opening in vertical shaft," "for opening in exterior wall," etc., which avoids arguments with municipal and insurance inspection authorities.

It is sometimes provided that instead of the use of a separate label, the words "Underwriters' Laboratories" and "Inspected" or "INSP" may be stamped, cast or moulded in the article. This variation is covered by the "Die Label Service Agreement," and has proved convenient to many manufacturers.

Finally, a few words as to the benefits of the combination label: The manufacturer has the advantage of using his own design; the Laboratories, ordering hundreds of millions of labels every year, is able to get lowest prices from etching or stamping companies; and above all the manufacturer gets the full advantage of the Laboratories' factory inspection service because he usually gets one hundred per cent. of his product labeled, which tends to do away with complications such as "seconds."

APPENDIX II

Underwriters' Laboratories and Instruction in Fire Protection Engineering

Insurance interests in 1903 caused the institution of a course in Fire Protection Engineering, because of the growing necessity for such instruction, and the growing need of high-grade men with more than a smattering of knowledge. They chose Chicago because of the presence of Underwriters' Laboratories; and Armour Institute for various good reasons. This combination of Armour Institute and the Laboratories provides unique facilities and opportunities for observation unobtainable anywhere else in the world. The students often see and test many devices in the experimental stage, some of which never are actually put on the market. The course lasts four years and leads to the degree of Bachelor of Science in Fire Protection Engineering. After three years of post-graduate work of a practical nature in connection with fire protection engineering—such as work in the Laboratories—and after submitting the usual appropriate thesis, the degree of Fire Protection Engineer is conferred by Armour Institute.

Every year the Western Actuarial Bureau awards twenty-five four-year scholarships for this course, so that there are always one hundred F. P. E. students thanks to this arrangement alone.

The Institute and the Laboratories coöperate constantly. For instance, during the school year Prof. Finnegan and Mr. O. L. Robinson divide their time between the Institute and the Laboratories. During the past seventeen years there have been five specialists thus jointly on the staffs of the Institute and the Laboratories.

Demonstrations

Besides this direct instruction work, the Laboratories advances the state of knowledge through frequent demonstrations and pro-

grams of tests arranged to coincide with the visits of members of societies holding conventions in Chicago, or making special trips to Chicago for the purpose of witnessing demonstrations and hearing lectures. Although this is only a side-line of activity on the part of the Laboratories it has grown to considerable proportions.

Thus, in the space of a little over one year, fifteen societies visited the Laboratories in a body, and in addition there were 236 individual members of societies, who came in smaller groups or even singly. This is not counting government, state, municipal and other public officials, thirty-eight of whom made special visits in that time, nor professors and students from institutions other than Armour Institute, who numbered respectively twenty-three and 396, and came from fourteen schools, colleges and universities.

Visitors Welcomed

Underwriters' Laboratories is always open to all visitors during office hours, one or more members of the staff always being available to conduct interested individuals or parties through the plant. In the period just referred to there were in addition to the officials, students, and others listed, eighty-seven miscellaneous visitors, not one of whom did not receive individual attention.

Of course, these figures do not include the thousands of business callers. They refer strictly to visitors coming to *learn*.

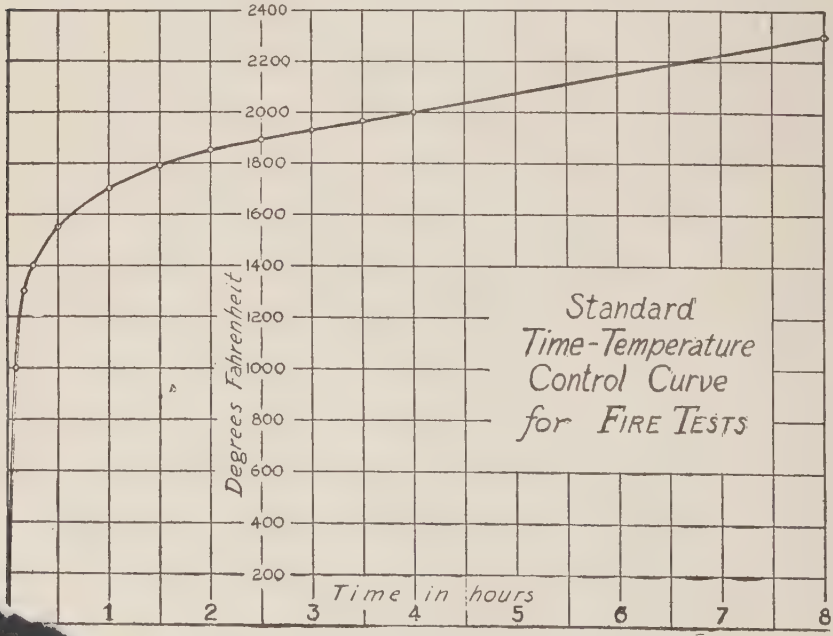
APPENDIX III

Standard Specifications for Fire Tests and Classification of Building Materials and Construction

ORIGINALLY used for the control of fire tests at Underwriters' Laboratories and the U. S. Bureau of Standards, these specifications were formally endorsed by the American Society for Testing Materials, American Society of Mechanical Engineers, American Concrete Institute, National Board of Fire Underwriters and Associated Factory Mutual Insurance Companies, and then printed and circulated among the 130-odd member societies of the National Fire Protection Association, meeting with practically unanimous approval.

The basis of the Specifications is the American Standard Time-Temperature Control Curve.

The universal endorsement of these Specifications means that fire tests conducted in any part of the country according to them will receive recognition by authoritative bodies.



Appendix III

"Incidentally," states the N. F. P. A., "it will be of financial advantage to the person or company having a test made."

The Specifications are published in pamphlet form by the N. F. P. A. Following is a summarized form:

Control of Fire Tests

The conduct of fire tests of materials and construction shall be controlled by the Standard Time-Temperature Control Curve.

The temperature fixed by the curve shall be deemed to be the average true temperature of the furnace gases as obtained from the readings of not less that three thermo-couples symmetrically disposed to show the temperature of the gases near all parts of the sample.

The temperatures shall be read at intervals not exceeding five minutes during the first hour, and thereafter not exceeding 15 minutes.

Classification as Determined by Test

Fire-resistive materials and construction shall be classified according to the degree of protection they afford when measured by a standard fire test, as

4 hour protection
2 hour protection
1 hour protection
½ hour protection
¼ hour protection

Other classes may be interpolated or added as needed.

Test Samples

The material or construction constituting the test sample shall be truly representative of regular practice.

Conduct of Tests

The fire test on the sample with its applied load, if any, shall be continued until failure occurs or until it has withstood the test conditions for a period equal to one and one-fourth times that for which classification is desired.

A second test with duplicate sample shall be made to determine the effect of a hose stream upon a sample under fire test, the water being applied at the end of a period equal to three-fourths of that for which classification is desired, but not later than one hour after the beginning of the test.

For classification periods of one-half hour or less the fire stream test may be omitted.

(The size of nozzle, water pressure, time of water application, changes in direction, etc., for floors, roofs, walls, columns and partitions, are given in the Specifications.)

For any material or construction intended to carry load other than its own weight the full rated safe working load shall be applied during the entire fire test, also during the fire stream test. After completion of the fire stream test, the sample shall be subjected to excess loading as prescribed under specifications for the different structural parts.

Floor and Roof Tests

Sample to be of such a size that the minimum span of the supporting beams of the floor arch shall be twelve feet; and supporting beams and girders shall have a clearance of at least eight inches from the walls of the test structure.

Floor may be tested as soon after construction as desired, but within forty days. Artificial drying allowed.

If construction is to be plastered in practice, sample shall be plastered in the same manner.

Floor shall be loaded in a manner to develop in each member of the construction stresses equal to the maximum safe working stress allowed in the material of the member.

Test shall not be regarded as successful unless following conditions are met:

(a) The floor or roof shall have sustained safely the full rated safe working load during the fire test without passage of flame, for a period equal to 1¼ times that for which classification is desired.

(b) The floor or roof shall have sustained safely the full rated safe working load during the firestream test without passage of flame, and after its completion shall sustain a total load equal to dead load plus 2½ times designated live load.

Non-Bearing Partition Tests

Area of sample shall be not less than 100 sq. ft. and no dimension less than 9-ft.

Temperatures on *outer* surface shall be read by not less than five thermometers, symmetrically disposed and placed against surface with bulbs protected against radiation of heat.

Test not regarded as successful unless following conditions are met:

(a) Partition shall have withstood safely the fire test for a period equal to 1¼ times that for which classification is desired.

(b) Shall have withstood fire stream test as prescribed.

(c) No fire shall have passed through partition.

(d) Temperature on outer surface during fire period not to have exceeded 300° F.

(e) Partition shall not have warped, bulged or distintegrated under action of fire or water to such an extent as to be unsafe.

APPENDIX IV

Demerits and Periodic Summaries

IN THE chapter on "The Significance of the Label," it was stated that the label "does not only mean that samples of the goods have been tested *once*, but that year after year these goods must continue to maintain their quality, or they will forfeit their right to the label."

The maintenance of high standards is assured by the Laboratories' follow-up service, whether it employ labels, as in the Label Service, or depend on other features, as in the Inspection and Reëxamination Services.

In several industries where the Label Service is employed, the number of manufacturers is so great, and their output is of such considerable volume, that it is possible to make up tally sheets, showing the relative standing of manufacturers and analyzing in great detail the results of factory inspections and tests, to the advantage of the industry, and, naturally, of the using public.

The Demerit System is a scientific method of analyzing and interpreting the data furnished by Label Service Department factory inspectors and by home office engineers who make routine tests. While it is complicated, its principal features are simple enough and will be set forth one by one.

Demerits

This term is self-explanatory. A manufacturer, receiving a report stating that his roofing material, or electric wire, or whatever product is under analysis, received 136 demerits during a certain period, while the average for all manufacturers of that product was 156, knows that in a general way his record is better than the average.

Demerit Factors

All products coming under the Demerit System receive a number of tests. Some of these are more important than others. Therefore, failures under the important tests are penalized by a greater number of demerits than failure under others. For example, in the case of a ready-to-lay roofing, failures under the item "Saturation Tests at Factory" are penalized several times more heavily that those under the item "Flash Point of Lap Cement."

Critical Points

For *every feature* of the routine investigation there is a definite "critical point," expressed in percentage of failures under test. When this percentage is exceeded, additional penalties are imposed. For example, under saturation tests of roofing, as mentioned above, the "critical point" is six per cent.: should one manufacturer's roofing samples show five per cent. of failures under this test during a given period, he would receive thirty demerits; but if during the following period his product fails in seven per cent. of the tests, he will receive no less than forty-eight demerits. In addition, the exceeding of the critical point in any feature of the investigation of any product is immediately called to the attention of designated engineers, who look into the matter and endeavor to help the manufacturer to remedy the factory conditions responsible for this bad showing.

Special Investigation Point

This is simply the point, expressed in demerits imposed for given periods, at which the manufacturer is notified—generally by telegraph—that he may no longer affix the Laboratories' label to his product. As implied in the expression, a special investigation of the factory is made, and it is a thorough one, designed to discover the reasons why drastic action was necessary—in other words the specific factory method conditions responsible for excessive failures under test. Generally, the discovery of these conditions makes their correction not only feasible but easy; and all ends well, with the resumption of Label Service.

Periodic Summaries

At stated intervals, all manufacturers in industries where the Demerit System is employed receive tally sheets showing their relative standing in comparison with their competitors. A way has been found of telling them this without violating the natural confidence of the Laboratories' relations. Each plant is designated by a secret "key" letter. The entire Summary Sheet is sent to all who are concerned, but each manufacturer is informed only of his own "key," and even that is changed in each successive summary. Thus he may measure the closeness of his approach to the "head of his class", or his danger of facing a special investigation.

Therein lies the principal value of the whole system: it serves to warn each manufacturer in ample time, and by analyzing all reports it points out accurately just what is the matter with the products which have rolled up a large number of demerits.

APPENDIX V

Special Forms of Service

DURING thirty years of growth it was natural that there should have been many demands upon Underwriters' Laboratories for extensions and modifications of its service. Consequently it has from time to time inaugurated various forms, which space limitations prevent describing in detail.

For example, there is the inspection of installations, which has reached a high state of development, especially in the fields of burglary protection systems and lightning rod installations. A self-explanatory report—one of those used in the latter field—is reproduced herewith. These reports are filled out by the installers, and on their reverse side there are printed in summarized form the Laboratories' requirements, which are to be read by the owner or occupant before countersigning. See also Page 109 with reference to the correction of substandard features.

Another form of service which must be mentioned is the utilization of the Laboratories' unique facilities not only in equipment but in personnel. This ranges from such notable investigations as described in the Chapter on Chemistry to simpler tests, examinations, analyses, etc., reports or records of results of which are furnished without comment or conclusions. Many clients regularly look to the Laboratories for tests of materials, photomicroscope service, calibration of steam, water, air and gas pressure gages, calibration of electrical instruments, determination of flash points, etc., etc. All this work is done at cost.

Report on Installation of LABELED Lightning Rod Material

Date of Installation 3./.20...1922

Manufactured by. Electra Lightning Rod Company. (And bearing the label of Underwriters' Laboratories) ..... Serial number of labels 50-458

Name of owner of building....Holy Trinity Church. (And postoffice address, street or R. F. D.) .....

Nearest R. R. station...Bloomington, Ill..... Direction ..... Distance ..... Miles

Township ..... County Mc.Lean..... State .Illinois.....

Description

Residence, barn, or other type....Church.....	Is soil clay, sand or rock?...Clay.....
Length 120'....width 60'.....height 45'-210'	Are tall trees near building?...No....distance.....
Wood, brick, or stone construction....Brick.....	Are telephone wires provided with lightning arrester?.....
Kind of roof. Slate Roof, Metal Deck, (State material of which roof is made)	Are metal fences or wires attached to building?...No....
Is roof pitched or flat?. Pitched.....	Are they properly grounded?.....

Construction

Kind of rod erected...Flat Ribbon Cable..... (Cable, tube or section rod)	Kind of rod fastener. Brass Screws & Leads... (Strap or fork type)
Kind of air terminals. Short Points.....	Average height of points.....14'!.....
Kind and number of points...18..... (Shell or solid)	Average distance apart....20'.....

Are chimneys, gables, cupolas, ventilators or other projecting parts protected with points?...Yes.....

No. of ground rods...7..... Are suitable guards provided for rods subject to displacement?...Yes- Wood (Kind) 7'.....

Depth

Ground No. 1.....Ground No. 2.....	Which method of grounding is used?.Carbon Electrode
" " 3..... " " 4.....	Are ground rods down to permanent moisture?..Yes....
" " 5..... " " 6.....	If a trench is required, give depth and length.....

All Groundings 10'

This is notification that we installed the system of Lightning Rods on the above building, using only material bearing the labels of Underwriters' Laboratories, and that the information supplied in this report is correct.

Chicago Conductor Co.
(Signature of Person or Firm that Installed Rods)

ATTEST OF MANUFACTURER:
We have checked the foregoing statements and believe the same to be correct. The material was installed by our Agent.

Date JUN 9 1922 Signed "ELECTRA" LIGHTNING ROD CO. H. A. Stehlik PRESIDENT

NOTICE TO OWNER OR OCCUPANT:—The general requirements are given on the other side of this report.

You are requested to examine the installation and carefully read the above report and if in your opinion the information is correct please sign below. Also give us the name of the Local Insurance Agent insuring this property.

Signed Chas. H. McCall & Son

Name of insurance agent Heffernan Agency, Johnson "

Postoffice address Bloomington, Ill

APPENDIX VI

Typical Labels

APPENDIX VII

Organization

Board of Directors

A. G. Dugan, Chicago, *Chairman*
F. C. Buswell.....New York
C. E. Dox.....Chicago
J. C. Harding.....Chicago
C. W. Higley.....Chicago
Ralph B. Ives.....Chicago
W. E. Mallalieu.....New York
John Marshall, Jr.....San Francisco
J. B. Morton.....Philadelphia
W. P. Robertson.....Chicago
O. E. Schaefer.....New York
H. A. Smith.....Hartford
W. H. Stevens.....Watertown, N. Y
Chas. R. Tuttle.....Chicago
W. H. Merrill, President.....Chicago

Officers

Chairman, A. G. Dugan, Chicago.
President, W. H. Merrill, Chicago.
Vice-President, Dana Pierce, New York.
Vice-President, A. R. Small, Chicago.
Secretary, D. B. Anderson, Chicago.
Treasurer, L. B. Headen, Chicago.

Technical Departments

Protection. Engineer, Fitzhugh Taylor; Division Engineer, R. K. Porter; Associate Engineer, J. B. Finnegan; Assistant Engineers, M. J. O'Brien, C. H. Pierson, A. J. Steiner, C. A. Menzel.

Hydraulic. Engineer, R. W. Hendricks; Assistant Engineers, A. W. Claussen, O. L. Robinson, E. L. Canman, E. P. Benjamin, H. A. Woelffer.

Gases and Oils. Engineer, E. J. Smith; Associate Engineer, C. R. Welborn; Assistant Engineers, R. B. Soyez, H. L. Pagett, S. C. Pinsler, G. M. Beard.

Chemistry. Chemical Engineer, A. H. Nuckolls; General Assistant Chemical Engineer, C. J. Krieger;* Assistant Chemical Engineer, A. E. Maitre; Special Chemist, C. A. Tibbals; Physical Chemist, A. F. Matson; Assistant Chemist, F. A. Martin; Assistant Electro-Chemical Engineer, D. T. Wright; Rubber Chemist, H. F. Klemm; Assistant Laboratory Chemists, A. M. Swanson, C. H. Eipert, R. L. Roe; Chemical Mechanician, G. Rierenthaler.

Electricity and Signals. Associate Engineers, B. H. Glover, R. B. Shepard;* Assistant Electrical Engineers, R. M. Obergfell, E. C. Goddard, C. W. Rulon,* F. F. Fleming,* R. T. Andersen;* Assistant Engineer, E. P. Slack.*

Casualty (including *Automotive* and *Burglary Protection*). Engineer, C. R. Alling; Mechanical Engineer, S. V. James; Associate Engineer, H. B. Michael;* Assistant Engineers, N. R. White, K. G. Leigh, F. C. Garrison, G. D. Becker, A. H. Bodenschatz, F. G. Coleman, R. S. Keeler.

Aviation. Aviation Engineer, R. W. Schroeder.

Label Service. Superintendent, C. R. D'Olive; Chief Inspectors, H. G. Ufer, R. A. Woodcock;* Reëxamination Engineer, W. J. Sharkey; Inspection Engineers, W. J. Alcock, E. A. Riesenberger.* 8 assistants and about 250 inspectors.

Office and Plant

Secretary, D. B. Anderson; Treasurer, L. B. Headen; General Agent, G. B. Muldaur; Assistant Secretaries, G. T. Bunker, B. E. Blanchard; Chief Clerk, N. S. Neal; Drafting and Photography, H. E. Rapp; Plant Foreman, F. Petersen.

(*) New York.

APPENDIX VIII

The Councils

If at the conclusion of the examination and tests of a submitted device, system or material by the engineers of Underwriters' Laboratories, the results are such as to lead to a recommendation for its recognition and listing as standard, such recommendation is made to one or more of the Laboratories' Councils.

There are five Councils, officially designated as Fire, Electrical, Casualty, Automobile and Burglary Protection. These designations indicate their respective scopes. Represented in their membership are federal, state and municipal governments and insurance organizations. The findings of the Laboratories' engineers are thus submitted to the judgment of men of wide field experience, whose impartiality is assured by a provision excluding from membership in any Council any official who might in any way be personally interested in the decisions for or against listing any device, system or material.

Councils render their decisions by letter ballots, mailed within a short time after every member has received a complete report from the engineers who conducted the investigations and tests.

In the event of unfavorable action by Council, or when the results of examinations and tests are such that a product cannot be recommended to Council for listing, no publicity is given in any manner; the manufacturer however receives a detailed report, in which reasons are set forth.

Fire Council

H. Foster Bain.....Washington, D. C.
Geo. W. Cleveland.....Detroit, Mich.
Gorham Dana.....Boston, Mass.
W. F. Dunbar.....Atlanta, Ga.
H. H. Glidden.....Chicago, Ill.
C. M. Goddard.....Boston, Mass.
C. O. Jost.....Montreal, Que.
C. A. Hexamer.....Philadelphia, Pa.
C. T. Ingalls.....Oklahoma City, Okla.
F. W. Jenness.....Syracuse, N. Y.
M. F. Jones.....Boston, Mass.
Geo. A. Madison.....St. Louis, Mo.
W. E. Mallalieu.....New York, N. Y.
W. H. Merrill.....Chicago, Ill.
Louis Harding.....New York, N. Y.
J. C. Mc Laughern.....San Francisco, Calif.
Isaac Osgood.....Boston, Mass.
H. L. Phillips.....Hartford, Conn.
Benjamin Richards.....Chicago, Ill.
W. O. Robb.....New York, N. Y.
E. M. Sellers.....Indianapolis, Ind.
T. B. Sellers.....Columbus, Ohio.
F. J. T. Stewart.....New York, N. Y.
C. C. Taylor.....Chicago, Ill.
P. W. Terry.....St. Louis, Mo.
R. J. Trimble.....Pittsburgh, Pa.
L. Wiederhold, Jr.....Philadelphia, Pa.
A. R. Small.....Chicago, Ill.

Casualty Council

L. L. Allen.....Nashville, Tenn.
H. Foster Bain.....Washington, D. C.
Lewis Bryant.....Trenton, N. J.
C. E. Connolly.....Oklahoma City, Okla.
R. J. Cullen.....New York, N. Y.
Byron Cummings.....New York, N. Y.
J. S. B. Davie.....Concord, N. H.
W. P. Eales.....Hartford, Conn.
R. H. Fletcher.....Lansing, Mich.
J. H. Garrett.....Boise, Idaho
Percy Gilbert.....Olympia, Wash.
C. H. Gram.....Salem, Ore.
R. H. Gunagan.....New York, N. Y.
R. S. Hayes.....Columbus, Ohio
F. A. Kennedy.....Lincoln, Neb.
F. W. Lawson.....Chicago, Ill.
John C. McCabe.....Detroit, Mich.
W. H. Merrill.....Chicago, Ill.
N. R. Moray.....Hartford, Conn.
Charles Nelson.....New York, N. Y.
Lew R. Palmer.....New York, N. Y.
R. H. Pearson.....New York, N. Y.
J. W. Rausch.....Baltimore, Md.
C. N. Smith.....Chicago, Ill.
G. D. Smith.....Carson City, Nev.
A. E. Spriggs.....Helena, Mont.
E. L. Sweetser.....Boston, Mass.
A. L. Urick.....Des Moines, Ia.
D. Van Schaack.....Hartford, Conn.
J. Walker.....Harrisburg, Pa.
A. W. Whitney.....New York, N. Y.
S. J. Williams.....Chicago, Ill.
E. E. Witte.....Madison, Wis.
H. M. Wolfin.....San Francisco, Calif.
J. R. Young.....Raleigh, N. C.

Electrical Council

L. A. Barley.....Denver, Colo.
H. N. Beecher.....Los Angeles, Calif.
W. S. Boyd.....Chicago, Ill.
F. R. Bradford.....Boston, Mass.
Walter J. Burke.....Boston, Mass.
F. A. Cambridge.....Winnipeg, Man.
M. E. Cheney.....Seattle, Wash.
B. W. Clark.....Detroit, Mich.
F. R. Daniel.....Milwaukee, Wis.
R. L. Daniel.....Minneapolis, Minn.
Washington Devereux.....Philadelphia, Pa.
F. O. Evertz.....Columbus, O.
J. H. Fenton.....St. Louis, Mo.
J. C. Forsyth.....New York, N. Y.
O. M. Frykman.....Minneapolis, Minn.
M. B. Gleeson.....Philadelphia, Pa.
B. H. Glover.....Chicago, Ill.
Warren Hadley.....Washington, D. C.
E. C. Waud.....Buffalo, N. Y.
D. M. Hosford.....Cleveland, O.
W. B. Hubbell.....Cincinnati, O.
L. C. Ilsley.....Pittsburgh, Pa.
W. W. Johnston.....Pittsburgh, Pa.
M. F. Jones.....Boston, Mass.
W. D. Matthews.....Chicago, Ill.
C. W. Mitchell.....San Francisco, Calif.
F. H. Moore.....Indianapolis, Ind.
I. Osgood.....Boston, Mass.
H. A. Patton.....Seattle, Wash.
Dana Pierce.....New York, N. Y.
A. M. Schoen.....Atlanta, Ga.
Wm. Lincoln Smith.....Boston, Mass.
R. P. Strong.....New Orleans, La.
H. H. Sutton.....Dallas, Tex.
Ralph Sweetland.....Boston, Mass.
C. M. Tait.....Montreal, Que.
V. H. Tousley.....Chicago, Ill.
F. D. Varnum.....St. Paul Minn.
W. W. Vaughn.....Syracuse, N. Y.
F. D. Weber.....Portland, Ore.
A. G. Wilbor.....Hartford, Conn.
W. W. Wise.....New York, N. Y.
H. S. Wynkoop.....New York, N. Y.

Automobile Council

F. D. Bennett.....Boston, Mass.
A. R. Goodale.....Hartford, Conn.
J. H. King.....Toronto, Ont.
T. A. Kruse.....New York, N. Y.
W. H. Merrill.....Chicago, Ill.
J. V. Parker.....Chicago, Ill.
A. Ryder.....New York, N. Y.
A. R. Small.....Chicago, Ill.
C. S. Timberlake.....Hartford, Conn.
Samuel Tupper, Jr.....Atlanta, Ga.
J. D. Vail.....Chicago, Ill.

Burglary Protection Council

R. A. Algire.....New York, N. Y.
C. R. Alling.....Chicago, Ill.
E. B. Anderson.....New York, N. Y.
S. B. Brewster.....New York, N. Y.
H. B. Michael.....New York, N. Y.
R. W. Meyers.....Hartford, Conn.
Dana Pierce.....New York, N. Y.

APPENDIX IX

Aeronautical Forms

W. H. MERRILL, PRESIDENT
W. C. ROBINSON, DANA PIERCE, A. R. SMALL, O. B. ANDERSON, SECRETARY
L. B. HEADEN, TREASURER
VICE-PRESIDENTS

CHICAGO, 207 E. OHIO ST.
NEW YORK, 25 CITY HALL PLACE
BOSTON, 87 MILL ST.
PITTSBURGH, 324 FOURTH AVE.
SAN FRANCISCO
205 MERCHANTS EXCHANGE BLDG.

Underwriters' Laboratories

INCORPORATED 1901
ESTABLISHED AND MAINTAINED BY THE
National Board of Fire Underwriters
FOR SERVICE - NOT PROFIT

Aircraft Register

This Certifies that the AIRCRAFT described below has been entered in
UNDERWRITERS' LABORATORIES' AIRCRAFT REGISTER
under the nationality and registration mark _____ as a _____
_____ having usual stations at _____

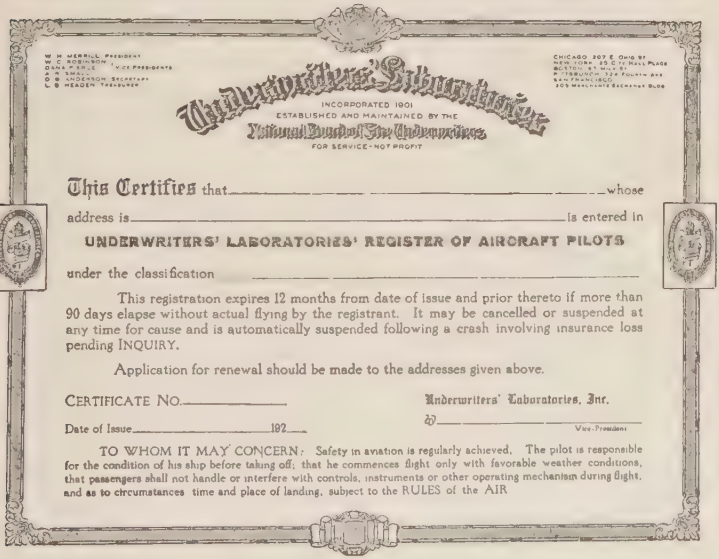
Owner _____ Operator _____
Mail _____ Mail _____
Telephone _____ Telephone _____

Underwriters' Laboratories, Inc.
By _____ Vice-President

Date _____ 192__

DESCRIPTION of REGISTERED AIRCRAFT

Manufacturer _____ Maker's Type No. _____ Serial No. _____
Over all Length _____ Feet Span _____ Feet Height over all _____ Feet
Dead Load _____ Lbs. Full Load _____ Lbs. Useful Load _____ Lbs.
Air Speed _____ M. P. H. Service Ceiling _____ Feet. Cruising Radius _____ Miles
Engines. Type _____ Number of _____ Registry Nos _____



W. H. MERRILL, PRESIDENT
W. C. ROBINSON, DANA PIERCE, A. R. SMALL, O. B. ANDERSON, SECRETARY
L. B. HEADEN, TREASURER
VICE-PRESIDENTS

CHICAGO, 207 E. OHIO ST.
NEW YORK, 25 CITY HALL PLACE
BOSTON, 87 MILL ST.
PITTSBURGH, 324 FOURTH AVE.
SAN FRANCISCO
205 MERCHANTS EXCHANGE BLDG.

Underwriters' Laboratories

INCORPORATED 1901
ESTABLISHED AND MAINTAINED BY THE
National Board of Fire Underwriters
FOR SERVICE - NOT PROFIT

This Certifies that _____ whose address is _____ is entered in
UNDERWRITERS' LABORATORIES' REGISTER OF AIRCRAFT PILOTS
under the classification _____

This registration expires 12 months from date of issue and prior thereto if more than 90 days elapse without actual flying by the registrant. It may be cancelled or suspended at any time for cause and is automatically suspended following a crash involving insurance loss pending INQUIRY.

Application for renewal should be made to the addresses given above.

CERTIFICATE NO. _____

Underwriters' Laboratories, Inc.
By _____ Vice-President

Date of Issue _____ 192__

TO WHOM IT MAY CONCERN: Safety in aviation is regularly achieved. The pilot is responsible for the condition of his ship before taking off; that he commences flight only with favorable weather conditions, that passengers shall not handle or interfere with controls, instruments or other operating mechanism during flight, and as to circumstances time and place of landing, subject to the RULES of the AIR

APPENDIX X

Underwriters' Laboratories' Bibliography

A. The Printed Reports

Fire Tests of Building Columns

This is the official story of the greatest single item of work accomplished at Underwriters' Laboratories—a task which involved years of work by a number of engineers. The furnace and related equipment were designed and constructed by the Laboratories during the period 1912 to 1917. Their use, except for repairs and replacements, was donated for the tests, which were conducted from 1917 to 1919. As early as 1910, preliminary work relative to the testing schedule had been begun; and it was not until 1921 that the report, as finally approved by the co-operating parties, was printed.

Its title in full is as follows: "Fire Tests of Building Columns by Associated Factory Mutual Fire Insurance Companies, The National Board of Fire Underwriters and the Bureau of Standards, Department of Commerce. An Experimental Investigation of the Resistance of Columns, Loaded and Exposed to Fire or to Fire and Water, with Record of Characteristic Effects. Jointly Conducted at Underwriters' Laboratories, Chicago, Illinois, 1917–1919."

There are nearly four hundred pages of type matter, illustrations and tables in the report. A general outline of the tests is given in the first section; Sections II, III and IV give descriptions of the 106 columns, column coverings and methods used in their preparation; Section V (and Appendix D), results of auxiliary tests of materials; Sections VI, VII, VIII and IX, descriptions of apparatus and methods of testing; Sections X and XI (and Appendices A, B and C), results of tests, and Sections XII and XIII, discussions of test data and conclusions. There are forty-six tables and 171 half-tones and line cuts. To cover the cost of getting out such a book, a charge of $2.00 is made for it bound in paper, and $2.50 bound in cloth.

Propagation of Flame in Pipes and Effectiveness of Arrestors

Many industries make use of tanks containing liquids which throw off vapors that are explosive when mixed with air. In some, these tanks are so connected by pipes that a spark in any portion of the system might result in a series of explosions, unless the "propagation of flame" were effectively intercepted by the right kind of "arrestors." The du Pont de Nemours Company, finding during the war that there was practically no information available on the subject, commissioned Underwriters' Laboratories to investigate it at its expense. The Laboratories' report has sixty-four pages and the famous Table of Constants is part of it.

Sisal

Large quantities of this fibre are imported annually through the port of New Orleans, and thousands of bales are being transported on ships or stored in warehouses. The Louisiana Fire Prevention Bureau and Messrs. Smyth, Sanford & Gerard of New York had the Laboratories conduct an investigation into the combustibility of sisal, its spontaneous heating, and conditions under which such spontaneous heating occurs and factors influencing it. As usual, the report is exhaustive and plentifully illustrated. Its thirty-two pages make interesting reading for anyone interested in the hazards of baled fibrous materials.

Inexpensive Fire-Resistive Interior Building Construction

(Report on Interior Building Construction Consisting of Metal Lath and Gypsum Plaster on Wood Supports. Associated Metal Lath Manufacturers and National Lumber Manufacturers' Association. Tests by A. R. Small, R. K. Porter, J. B. Finnegan and M. J. O'Brien, Underwriters' Laboratories. August 10, 1922. 120 Pages. 56 half-tone and line illustrations.)

This investigation was begun several years ago by the late William C. Robinson, Vice-President and for twenty years Chief Engineer of Underwriters' Laboratories. The report shows that his long-cherished dream has come true: a combination of materials has been found whereby dwelling houses and small buildings can be built with both economy and fire-safety. This is the first investigation of importance as to scope, cost and potential effects, in which the Standard Classification as to time has been used, and the recommendations were based thereon.

Carbon Tetrachloride Extinguisher Liquids

(Report on Corrosive Action and Nature of Products Formed when Carbon Tetrachloride Extinguisher Liquids are Applied to Fires. Special Investigation No. 42, August 24, 1920 20 pp.)

This investigation was restricted to those liquids which comply with Underwriters' Laboratories' Standard specifications, requiring freedom from impurities and substances which act as corrosives and toxics. The various approved liquids were used on wood, gasolene and alcohol fires in a special furnace, and the products were drawn off into chemical apparatus where they were thoroughly analyzed. The report covers this subject exhaustively, and is generously illustrated.

Sheetrock

This product of the United States Gypsum Company is a familiar wall and ceiling material,

applied directly on the joists and studs of frame construction. The manufacturers submitted it for listing as Standard, and in 1921 had the report printed by the Laboratories. It is nearly one hundred pages in length and is copiously illustrated.

Herring-Hall-Marvin Fire-Resisting Safes

There are two separate pamphlets, of seventy-two pages each, dealing with Class A and Class B safes, respectively.

The Haley Process of Fireproofing Gin-Baled Cotton

Besides giving complete details of this invention and describing the standard equipment for dipping cotton bales in the fireproofing solution, the report tells the story of such tests as Spark, Flame, Spraying, Country Damage, Penetration, etc. There are 108 pages in the booklet, which includes useful tables and appendices.

B. The Standards

As the volume of work on any device grows, it is found convenient to mimeograph or print the Laboratories' requirements as to construction, performance under test and method of factory inspection or periodical reëxaminations. This has been the case for over seventy devices.

A typical Standard—that for Safes and Insulated Cabinets—is printed as Appendix XIII, pages 266 to 284. Some are longer, as, for instance, that for Rubber-Covered Wires, which takes up ninety printed pages in addition to the thirty introductory pages of the assembled electrical Standards. A few are shorter. All are thorough and explicit. All have been submitted to the Councils and Industry Conferences concerned before being issued.

Anyone may obtain a copy of any of the following Standards, which are uniformly priced at One Dollar.

Electrical

Armored Cables and Cords
Bell Ringing Transformers
Cabinets and Cutout Boxes
Cartridge Enclosed Fuses
Christmas Tree Lighting Outfits
Circuit Breakers (Air Break Type)
Cleats, Knobs and Tubes
Control Appliances (Resistance Type)
Control Appliances (Transformer Type)
Cutout Bases
Electric Bells
Electric Lighting Plants
Electric Ranges
Electric Signs
Fixture Wires
Flexible Cords
Flexible Cord (Type S, Rubber Sheathed)
Flexible Metallic Conduit
Flexible Non-Metallic Conduit
Ground Clamps
Heater Cord
Insulating Joints (Construction and Installation of—)
Knife Switches
Lightning Rod Equipments, Materials for, Construction and Installation of
Metal Raceways for Surface Wiring
Motion Picture Cable and Stove Wire
Musical Instruments
Panelboards
Renewable Cartridge Enclosed Fuses
Rigid Conduit
Rubber Covered Wires and Cables
Slowburning, and Slowburning-Weatherproof Wires
Snap Switches
Soldering Lugs
Toy Transformers
Transformers (Not Oil-Immersed Type)
Transformers (Oil-Immersed Type)
Varnished Cloth Cable
Wooden Raceways for Surface Wiring

Building Materials

Note—With the nearly universal adoption of the National Standard Time-Temperature Control Curve, individual Standards for materials subjected to the Laboratories' standardized fire tests become almost unnecessary.

Counterbalanced Elevator Doors
Gypsum Blocks
Gypsum Wall Board

Fire-Fighting Equipment

Angle Type Hose Valves
Automatic Sprinklers
Chemical Engine Hose
Cotton-Jacketed Rubber-Lined Fire Hose
Fire Hose Couplings
Five-Gallon Hand Pump Fire Extinguishers
Indicator Posts
Loose-Stopple 2½-Gallon Fire Extinguishers
Non-Rising Stem Valves for Underground Work
Outside Screw and Yoke Gate Valves
Play Pipes
Rubber Discs for Dry-Pipe and Alarm Valves
Straightway Hose Valves
Swing Check Valves (Regular Pattern)
Swing Check Valves (Special)
Unlined Fire Hose

Appliances for Use of Hazardous Substances

Gas Garage Heaters, Class C
Gasolene Hose Couplings
High Pressure Gauges for Oxy-Acetylene Welding and Cutting Apparatus
Lighting Acetylene Generators
Non-Recording Spring Pressure Gauges
Rubber Gasolene Hose
Rubber-Metal Gasolene Hose
Stationary Acetylene Generators, Pressure Regulators, Blowpipes and Fittings,—for Oxy-Acetylene Welding and Cutting

Chemical

Oxygen and Hydrogen for Industrial Uses, and Electrolytic Oxygen and Hydrogen Plants and Their Equipment.

There are also many other manufactured devices which are tested and inspected by the Laboratories under requirements which have not as yet been printed or mimeographed, but which are based on rules originating with the National Board of Fire Underwriters. The Laboratories' report includes in these cases a recommendation, primarily for the information of underwriters, as to the introduction and use of the device, and a report on its status or classification under National Board rules.

C. Lists of Inspected Appliances and Card Reports Thereon

LARGE editions of semi-annually revised lists of manufacturers of material being constructed in accordance with the Laboratories' Standards and subject to one of the forms of continuous supervision by Laboratories' inspectors and engineers, as described on pages 22, 41-43 and 274-277, are widely distributed. The following lists are regularly published:

List of Inspected Electrical Appliances.
List of Inspected Mechanical Appliances.
List of Inspected Automotive Appliances.
List of Appliances Inspected for Accident Hazard.

Card Reports. Summaries of the Laboratories' reports are promulgated on printed cards filed according to classifications, and cabinets containing these cards are maintained at the offices of the principal boards of underwriters and inspection bureaus in the United States, at many of the general offices of insurance companies and firms, certain Federal, state and municipal departments, and at the offices and agencies of the Laboratories in larger cities.

A copy of this card report is also forwarded to the submittor, who may obtain additional copies at printing cost.

D. Miscellaneous

Fire-Prevention Chemistry

This handbook is now in course of preparation by the Chemistry Department of the Laboratories.

Motion Picture Films

The Laboratories has two films, "An Unbeliever Convinced" and "Fire and Safety Appliances Testing at Underwriters' Laboratories." That they are interesting may be judged from the fact that in 1922 they were shown to 100,000 people.

"Laboratories' Data"

This is a monthly twenty-four page magazine, primarily in the nature of a house organ but of interest to many not of the "Laboratories' family." Subscription, One Dollar a year. An index of selected articles which have already appeared therein is given below.

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APPENDIX XI

Tabulated Summary of Column Investigation Results

Type of Column	Protection		Minimum Area of Solid Material Sq. In.	Nominal Thickness of Protection, In.	Fire Resistance Period
	Material	Details			
Structural steel	Unprotected	Minimum metal thickness, .20 in.	8	.....	10 min.
Structural steel, solid section	Partly protected by filling reëntrant spaces with concrete. Concrete aggregates; limestone, calcareous gravel, trap rock, granite, sandstone or hard coal cinder	Mixture, 1:6 or 1:8. Concrete tied with vertical and horizontal steel ties	35	.....	½ hr.
Structural steel, solid section	Partly protected by filling reëntrant spaces with concrete. Aggregates; limestone, calcareous gravel or trap rock	do	60	.....	¾ hr.
Structural steel, open latticed section	Partly protected by filling interior and reëntrant spaces with concrete; trap rock aggregate	Mixture, 1:6. Filling extends to outside rivets and covers lattice and main members	120	.....	2 hr.
Structural steel, open latticed section	Partly protected by filling interior and reëntrant spaces with concrete; limestone or calcareous gravel aggregate	do	120	.....	3½ hr.
Structural steel	Portland cement plaster on metal lath	Proportion of plaster, 1:1-10:2½, Portland cement, hydrated lime and sand	40	1 layer 1 in.	¾ hr.
Structural steel	do	do	80	2 layers each ½ in.	1½ hr.
Structural steel	Concrete, siliceous gravel aggregate	Mixture, 1:6. Concrete tied with steel ties or wire mesh equivalent to not less than No. 5 (B. & S. gage) wire on 8 in. pitch	100	2	1 hr.
Structural steel	do	do	200	4	2½ hr.
Structural steel	Concrete; granite, sandstone or hard coal cinder aggregate	Mixture, 1:6. Concrete tied as above	100	2	2½ hr.
Structural steel	do	do	140	3	3½ hr.
Structural steel	do	do	200	4	5 hr.
Structural steel	Concrete, trap rock aggregate	Mixture, 1:6. Concrete tied as above	100	2	3 hr.
Structural steel	do	do	140	3	4 hr.
Structural steel	do	do	200	4	5 hr.

Structural steel	Concrete: limestone or calcareous gravel aggregate	Mixture, 1:6. Concrete tied as above	100	2	4 hr.
Structural steel	do	do	140	3	6 hr.
Structural steel	do	do	200	4	8 hr.
Structural steel, solid section	Hollow tile; semi-fire clay, medium hard. No filling	Mortar joint between tile and column flanges. Outside wire ties	80	2, 3 or 4	1 hr.
Structural steel, solid section	Hollow tile:surface clay or shale. Concrete filling on web sides	do	100	2, 3 or 4	1 hr.
Structural steel, solid	Hollow tile, extra heavy; surface clay. Concrete filling on web sides	do	160	3 or 4	1½ hr.
Structural steel	Hollow tile; semi-fire cay or surface clay. Concrete filling all around	Outside wire ties	160	2, 3 or 4	2 hr.
Structural steel	do	Metal ties in horizontal joints	160	3 or 4	2½ hr.
Structural steel, solid section	Hollow tile; surface clay. Hollow tile filling	Mortar joint between tile and column flanges and webs. Metal ties in horizontal joints	240	2 layers each 2 in.	3 hr.
Structural steel, solid section	do	Mortar joint between tile and column flanges and webs. Outside wire ties	240	2 layers each 2 in.	1 hr.
Structural steel	Common brick; surface clay	Brick set on edge and end	140	2¼	1 hr.
Structural steel	do	Brick laid on side	240	3¾	5 hr.
Structural steel	Solid gypsum block. Gypsum block or poured gypsum filling	Metal ties in horizontal joints. Mortar joint between blocks and column flanges	130	2	1½ hr.
Structural steel	do	do	180	3	2½ hr.
Structural steel	do	do	240	4	3½ hr.
Round cast iron	Unprotected; unfilled	Minimum thickness of metal, .60 in.	12	.....	20 min.
Round cast iron	Unprotected: interior filled with concrete	do	35	.....	½ hr.
Round cast iron	Portland cement plaster on high ribbed metal lath	Proportion of plaster, 1:$\frac{1}{10}$:2½. Portland cement, hydrated lime and sand	60	1 layer, 1½ in. ¾ in. air space	2 hr.
Round cast iron	Concrete; trap rock, granite or hard coal cinder aggregate	Mixture ,1:7. Concrete tied with steel ties equivalent to not less than No. 5 (B. & S. gage) wire on 8 in. pitch	70	2	2 hr.
Round cast iron	Hollow tile; porous semi-fire clay	Outside wire ties. Mortar joint between tile and column	70	2	2 hr.
Steel pipe	Unprotected Filled with concrete	Concrete mixture, 1:1½:3	35	.....	25 min.
Reinforced steel pipe	Unprotected. Filled with concrete and reinforced in the fill with structural ishapes	Concrete mixture, 1:1½:3	45	.....	¾ hr.
Reinforced concrete	Limestone or calcareous gravel concrete	Mixture 1:6. Concrete reinforced with vertical bars and lateral ties or hooping	220	2	8 hr.
Reinforced concrete	Trap rock concrete	do	220	2	5 hr.
Timber, longleaf pine or Douglas fir	Unprotected	Unprotected cast iron or steel cap	120	.....	25 min.
Timber, longleaf pine or Douglas fir	Gypsum wall board	Cast iron or steel cap	140	1 layer ⅜ in.	¼ in.
Timber, longleaf pine or Douglas fir	Portland cement plaster on metal lath	Cast iron or steel cap. Proportion of plaster, 1:$\frac{1}{10}$:2½, Portland cement, hydrated lime and sand	160	1 layer, 1 in. with ¾ in. air space	1½ hr.

APPENDIX XII

Typical Underwriters' Laboratories' Specifications

Specifications of the Fire Department of the City of for 2½-in. double-jacketed cotton rubber-lined fire hose.

I.—PURPOSE

For Use by the Fire Department of the City of

II.—CONSTRUCTION

(*a*) *Hose in General.* The hose shall be made of a cotton cover and rubber lining and shall be at least 2½ in. in internal diameter and nominally 50 ft. in length.

The name of the manufacturer, the trade name of the hose, together with the month and year of manufacture, and the words "Tested to 400 Pounds" shall be stenciled upon every section twice in each 50 ft. length, with indelible letters and figures at least 1 in. in height. These marks to begin approximately 24 in. from the couplings. Each length shall also bear the label of Underwriters' Laboratories firmly attached near one coupling.

(*b*) *Rubber Lining.* The lining shall consist of not less than three calendered sheets and shall be lap-jointed, with the lap as small and neat as is consistent with the best results. When inspected at the factory it shall be shown to be of uniform thickness and not less than 0.058 in. thick and not more than 0.072 in. thick, both dimensions exclusive of the backing. It shall be practically free from corrugations.

(*c*) *Cotton Cover.* The cotton cover shall be of two plies separate or interwoven each circular made and seamless, and having large filler strands composed of many threads which shall be woven around the hose throughout its length, and shall have warp threads composed of several fine threads interwoven with the filler strands.

Note.—It is not the intention to debar under these specifications any form of cotton cover which is not accurately described as "two ply separate or interwoven circular made and seamless." Any form of cotton cover which is shown by tests and examinations made in the factory inspection of the hose by Underwriters' Laboratories as the authorized agent of the city to conform, because of strength and weight, to the requirements of Sections II-(e) and IV-(a), shall be considered as included in this description.

(*d*) *Fittings.* Each length of hose shall be fitted with couplings conforming to the standards for weight and quality of metal, for dimensions and for threads of the couplings now in use in the fire departments of the city. The hose shall be expanded into the couplings in a workmanlike manner without cutting the rubber or rupturing the cotton cover. After attachment the couplings shall be tested at the factory by Underwriters' Laboratories, the authorized representative of the city, and when so tested shall withstand the pressure test described in Section IV-(a) below, without the use of tape or rubber tissue as a filler. Each coupling shall be provided with accurately fitted rubber gaskets both inside the coupling and at the end of the hose beneath the expansion ring.

(*e*) *Weight of Hose.* Each 50-ft. length, complete with couplings, shall be found on inspection and test at the factory by Underwriters' Laboratories, the authorized representative of the city, to weigh not more than 70 lbs.

III. MATERIAL

(*a*) *Cotton Cover.* The cotton cover shall be well, evenly and firmly made from good cotton. It shall be examined at the factory by Underwriters' Laboratories, the authorized representative of the city, and the label as evidence of inspection and acceptance shall not be allowed for any length of hose, the cotton cover of which is not found as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice.

(*b*) *Rubber Lining.* 1. The rubber lining shall be made of a properly vulcanized rubber compound, which when tested by Underwriters' Laboratories, the authorized representative of the city, in connection with the factory inspection and label service, shall sustain all of the tests required in Section IV-(b), 2.

2. The backing, if used, must not exceed 0.028 in. in thickness. It need not be of the same composition as the rubber lining, provided the adhesion between the rubber lining and the cotton jacket, when tested at the factory by Underwriters' Laboratories, the authorized representative of the city, under the factory inspection and label service, is found to be such as to meet the tests required under Section IV-(b), 1.

IV. TESTS

All tests, both on the hose as a whole and on individual parts, shall be performed according to "Underwriters' Laboratories' Standard Procedure for Methods and Machines for Testing Rubber-Lined Fire Hose."

(A) HYDRAULIC PRESSURE TESTS ON THE HOSE AS A WHOLE

1. *Elongation and Twist.* Each length, with coupling attached, shall be subjected to a pressure test of 400 lb. per sq. in. This test, which shall be made at the factory in the presence and under the supervision of Underwriters' Laboratories, the authorized representative of the city, is to expose imperfections and to insure proper attachment of the couplings.

During the test any length of hose which is shipped out with the labels attached as evidence of inspection and acceptance must not leak, sweat, or break the threads of the cotton cover. It must not contract in length or diameter, rise from the level of the test table, or warp more than 20 in. from a straight line drawn from coupling to coupling. The limit of elongation shall be 9 per cent. of the original length, and it shall not turn more than 15 deg. per foot. The twist must be in a direction to tighten rather than loosen the couplings.

2. *Kinking.* One full length in every ten lengths shall be tested while kinked. The test is to be made at the factory in the presence and under the supervision of Underwriters' Laboratories, the authorized representative of the city. When so tested the threads of the cotton cover of any length, shipped out with

the label attached as evidence of inspection and acceptance, must not break at a pressure below 300 lb. per sq. in.

3. *Bursting Strength Lying Straight or Curved.* From every lot of 60 lengths, or less, one sample, 3 ft. in length, shall be cut from a length selected at random, and be tested at the factory as follows, in the presence of and under the supervision of Underwriters' Laboratories, the authorized representative of the city. The sample shall be tested in the lying straight position or while curved to a radius of 27 in. When so tested the cotton cover of any length shipped out with the label attached as evidence of inspection and acceptance must not break at a pressure below 600 lb. per sq. in.

(B) TESTS OF THE RUBBER COMPOUND

Sections 8 in. long shall be cut from any length at any place for the following tests of the rubber compounds. All tests shall be made by Underwriters' Laboratories, the authorized representative of the city, in connection with the inspections at the factory and the labeling of the hose.

1. *Friction Compound.* The adhesion of the lining to the cotton cover shall be such that a weight of 12 lb. shall not cause the rubber to separate from the cotton cover at a greater rate than 1 in. per min. The width of the piece under test shall be 1½ in.

2. *Rubber Lining.* (*w*) *Physical Tests When New* (*Less than One Month from Date of Final Vulcanization.*) After the test piece is held stretched from 2 to 10 in. for 10 min. the permanent elongation 10 min. after release must not exceed 25 per cent. The tensile strength of the rubber lining of any hose shipped out with the label attached as evidence of inspection at the factory by Underwriters' Laboratories, the authorized representative of the city, must be at least 1,600 lb. per sq. in., and the elongation at the breaking point must be at least 2 to 12 in.

(*x*) *Physical Tests Up to One Year from Date of Labeling.* Sample pieces cut from lengths of labeled hose and submitted to Underwriters' Laboratories, in accordance with its Field Follow Up System, must show a permanent elongation 10 min. after release of not more than 25 per cent. when the test piece is held stretched from 2 to 8 in. for 10 min. The tensile strength of such sample test pieces must be at least 1,200 lb. and the elongation of the breaking point must be at least 2 to 10 in.

(*y*) *Life Test Within Three Months After Labeling.* After being subjected to a dry heat of 158° F. for a period of four days of 24 hours each, test pieces cut from the rubber linings of hose shipped with the label attached, as evidence of inspection by Underwriters' Laboratories, at the factory must have a tensile strength of at least 900 lb. per sq. in.

(*z*) *Chemical Test.* Five chemical tests shall be made as follows:

Acetone Extract, Alcoholic Potash Extract, Chloroform Extract, Ash and Total Sulphur. The sum total of the results of the five tests must not exceed 67 per cent. by weight of the total compound and the free sulphur must not exceed 1½ per cent. by weight of the total compound.

The Acetone Extract must not exceed 4 per cent.; the Alcoholic Potash Extract must not exceed 1½ per cent.; the Chloroform Extract must not exceed 2 per cent.; the Total Sulphur, exclusive of barytes, must not exceed 4 per cent.; and the Ash must not exceed 57 per cent. or be less than 50 per cent.: all percentages to be by weight of the total compound. Tests to be made according to the "Underwriters' Laboratories' Standard Procedure for Chemical Test of Rubber Linings for Fire Hose."

V. INSPECTION AND ACCEPTANCE

(*a*) *Inspection at Factory.* Inspection of hose under the requirements of the preceding section will be carried out at the factory or factories where the hose is made by Underwriters' Laboratories, and according to its "Procedure for Inspections at Factories and Labeling Rubber-Lined Fire Hose."

(*b*) *Appointed Representative.* Underwriters' Laboratories, of Chicago, Illinois, is hereby designated as the duly authorized representative of the City of.....and will conduct for the City of...under its Label Service, the tests called for.

(*c*) *Identification.* Each length of hose delivered must bear the label of Underwriters' Laboratories, as evidence of its having been examined and tested by the duly authorized representative of the City of.....and passed as in conformity with the foregoing requirements.

(*d*) *Acceptance.* Acceptance of the hose is conditioned upon the receipt by the City of .....from Underwriters' Laboratories, acting as the duly authorized representative of the City of.....of notice of labeling and summary of record of examination and tests.

VI. CONDITIONS OF PURCHASE

(*a*) *Amount.* Bids are wanted for a total of .....ft. (.....lengths) more or less of 2½ in. double-jacketed Cotton Rubber-Lined Fire Hose, labeled by Underwriters' Laboratories, as conforming to the foregoing specifications.

(*b*) *Place of Delivery.* Hose to be delivered free of all carrying charges to.....City of .....State of.....

(*c*) *Time of Delivery.* Final shipment completing order to be delivered at the above point not later than.....

(*d*) *Sealed Proposals.* Sealed proposals stating name of the actual manufacturer of the hose and the price asked per foot of labeled hose, complete with couplings, and delivered, will be received until.....at the office of.....

(*e*) *Bond with Proposal.* Each proposal shall be accompanied by a bond or certified check drawn payable to the City of.....to an amount not less than.....per cent. of the total price named in the bid, as a deposit in evidence of good faith. Said bonds or checks will be returned to all unsuccessful bidders.

(*f*) *Bond for Delivery.* The bond or certified check deposited by the successful bidder will be retained by the city until the delivery of the full amount of labeled hose.

(*g*) *Awarding of Order.* Bids received will be opened at the office of.....on.....All other things being equal, orders will be given to the lowest bidder or bidders. The....reserves the right, however, to reject any or all bids not deemed to the best interest of the City of.....

(*h*) *Guarantee.* The manufacturer shall guarantee that the hose is made according to the best principles of hose construction, and that it is free from defects of material and workmanship. If at any time within a period of three years the rubber parts of any section or sections of it burst, or show upon examination cracks or hardening due to defects of material or workmanship, and not incident to the customary wear and tear of service or improper storage or care, such hose shall be replaced by the contractor with new hose at cost to the City of.....equal to that per cent. of the original cost as the time is to three years.

APPENDIX XIII

A Typical Standard—That for Safes and Insulated Cabinets

SECTION 1

UNDERWRITERS' LABORATORIES STANDARD TEST APPARATUS FOR SAFES AND INSULATED CABINETS

This section of the Standard includes a general description of the equipment and apparatus regularly employed by Underwriters' Laboratories in the tests and investigations of Safes and Insulated Cabinets.

Introductory

General: Underwriters' Laboratories, a corporation chartered November 1901, by the State of Illinois, is authorized to establish and maintain laboratories for the examination and testing of appliances and devices.

Underwriters' Laboratories was established by, and is maintained by the National Board of Fire Underwriters, For Service—Not Profit.

The object of Underwriters' Laboratories is to bring to the user the best obtainable opinion on the merits of appliances, devices, machines and materials in respect to life and fire hazards and accident prevention.

The work is undertaken as one means of reducing the enormous and disproportionate loss of life and property by fire and the number of accidents in America.

A complete description of the organization, purpose and methods of Underwriters' Laboratories is printed in a separate pamphlet, copies of which may be obtained upon request.

This Standard. This Standard comprises the programs employed by Underwriters' Laboratories in the examination, test and classification of safes and insulated cabinets and the methods of follow-up and labeling. The various sections of the standard are as follows:

Section I —General Description of Equipment and Apparatus employed in the tests and investigation of Safes and Insulated Cabinets.

Section II —Description of prescribed and standard examination and test procedures to ascertain compliance with standards of construction and performance under tests for the various classes of Safes and for Insulated Cabinets.

Section III—The classification of Safes and Insulated Cabinets and standard specifications for construction and performance under tests for the various classes.

Section IV—General description of Label Service Procedure.

Section V —Description of Standard Label Service Procedure for Safes and Insulated Cabinets.

Investigation of Safes and Insulated Cabinets

Preliminary Arrangements. A manufacturer desirous of securing an investigation of his Safes or Insulated Cabinets may do so by first depositing a preliminary fee as evidence of good faith and on completion of the work paying the balance of its cost as shown by accurate records thereof, which are kept in detail. As a warrant that an applicant will not incur costs beyond his expectations, a limit of expense is fixed in each case beyond which charges are not made. By this means an opportunity is afforded anyone at comparatively low cost to secure the opinion of the recognized authorities covering his product in its relation to the fire hazard.

The preliminary fee for the tests, investigations and report on Safes and Insulated Cabinets is one hundred dollars ($100.00), such devices being in group F of the Laboratories schedule of fees listed on the enclosed application blank.

The costs are in proportion to the work required for the investigation and report whether the safes or cabinets show superior or inferior qualities. The applicant's obligation to pay the charges is not, therefore, contingent on the nature of the opinion rendered whether favorable or otherwise. If for any reason the costs do not aggregate the amount of the preliminary fee, the balance will be returned to the applicant.

Blank forms for use in making applications for investigations of Safes and Insulated Cabinets are furnished on request.

Required for the Investigation. The following information and test samples are necessary for the tests, investigations and report on Safes and Insulated Cabinets:

(*a*) *Drawings and Specifications*—Detailed drawings and specifications of a medium size safe of each class submitted.

(*b*) *Sizes and Weights*—A list giving the exterior and interior dimensions and the weights of each size of the classes of safes or insulated cabinet submitted.

(*c*) *Instructions*—Instructions for packing, shipping, handling, installation, operation and maintenance of the safes or cabinets submitted.

(*d*) *Test Samples*—At least two safes of each class submitted, or at least one insulated cabinet are required for the examinations and tests. One of the safes of each class to be of medium size and one to be of the largest size provided this does not exceed 7 feet high, 5 feet wide and 3 feet deep. Insulated cabinets to be of medium size.

An additional safe or cabinet of medium size may be necessary if the tests and investigation indicate that a fire stream test is advisable.

Heat insulating materials and other special materials are required in sufficient quantities for any separate tests necessary for the report.

Test samples should not be made or shipped until the Laboratories have had opportunity to study the drawings and specifications, inspect the application of the insulation, pass on the special connections for the introduction of the apparatus for the measurement of the internal temperatures, and on the suitability of the condition of the samples for test.

Safes or cabinets submitted for test must accurately represent the commercial product and should be shipped to the Laboratories in the same manner that such product is ordinarily shipped.

(*e*) *Claims*—A list of the claims made for the safes or cabinets, including statements covering the situations for which they are advocated and considered capable of safeguarding against the fire and impact hazards.

(*f*) *Service Record*—If the safes or cabinets have been on the market, a list of users should be furnished, and also any reports covering their performance in actual fires.

Report on Investigation. If the results of the investigation of any single sample or set of samples are favorable, a report is prepared in which definite recommendations for action are made to the Fire Council of the Laboratories by whom the report is reviewed and by whom action on the recommendation is taken. If at any time the results of the investigation show that improvements are necessary, a report is sent to the Submittor setting forth the particulars in which the device does not comply with the Standard.

The report includes a general description of the safes or cabinets submitted, a list of the claims made for the product, the results of the tests and investigations made, a brief statement relative to the Manufacturer, a comprehensive conclusion covering each phase of the investigation, and the recommendations made.

Listing of Safes and Insulated Cabinets. When as the result of investigation, the product of the manufacturer has been judged to comply with the requirements of Standard of the Laboratories for the product, and the Fire Council has concurred in the recommendations in the report, a card is promulgated to subscribers announcing the listing of the product as standard under the proper classifications.

The name of the manufacturer is also included in the List of Inspected Mechanical Appliances which is promulgated semi-annually.

At the request of the manufacturer and at the cost of printing, the Underwriters' Laboratories will furnish printed copies of the official report in the numbers desired.

Supervision of Listed Safes or Insulated Cabinets. The Label Service is employed in the supervision of Listed Safes and Insulated Cabinets. This Service is described in later sections of this Standard.

Underwriters' Laboratories' Standard Test Apparatus for Safes and Insulated Cabinets

The equipment employed in the tests of devices and materials that may be exposed to fire is located in several of the Laboratories' buildings, but the greater portion is in a building specially designed for work of this character known as Building No. 3.

Building No. Three. This building is of fireproof construction having a steel frame protected by concrete and enclosed by brick and reinforced concrete walls. The ground floor is of concrete and the upper floor and roof of reinforced concrete. Sliding skylights that can be opened for ventilation are located over the central and southern portions of the building. The windows are metal, glazed with wired glass.

The building has a ground area of 69 by 70 feet and is one and two stories high, the maximum height being equivalent to three stories. The central portion is one high story, furnishing head room of approximately 37 feet. At three sides of this portion the building is two stories with head room of approximately 17½ feet under the second floor. A brick tower 53¾ feet high which can be partly opened to the air at the top is located in the southeast corner of the building, and three brick stacks 58 feet high are built in the brick wall adjoining the tower.

A trench for pipes and conduits extends around the four sides of the building. Removable reinforced concrete covers are provided to permit access to the trench.

The first story is undivided, except in the south-eastern portion in front of the tower which is separated from the main room by partitions and a large rolling steel door. The second story is open to the high central portion except a room on the south side which is enclosed by metal lath and cement plaster partitions.

The first story of the building is devoted to the tests of devices and materials requiring the use of furnaces, and to the preparation of test samples for these furnaces. Ten furnaces of different sizes specially designed for test units ranging from full size building columns to 10 feet by 12 feet panels and to the smaller devices and building material units, are located in various parts of the building.

The second story is used for the preparation of test samples and the location of the fans, pumps and tanks supplying air to the test furnaces and pressure to the apparatus by means of which some of the test samples are subjected to loads.

Apparatus

The apparatus used in the tests of safes and insulated cabinets consists of a furnace in which the test samples are subjected to the Fire Test and in which they are heated before and after the Impact Test; apparatus for measuring the temperatures in the furnace and on the interior of the safes or cabinets; an electric hoist, derrick, slings and tripping device for use in the Impact Tests; a hydrant and flexible nozzle for use when Fire Stream Tests are made, and the apparatus for testing the materials employed in the safes or cabinets submitted.

Furnace No. 3. The furnace employed in the tests of safes and cabinets is known as Furnace No. 3. The furnace proper consists of a combustion chamber approximately 6 feet wide, 4 feet deep and 8 feet high inclosed at the back and sides by solid brick walls and in front by a swinging door consisting of a steel frame filled with brick. The top of the furnace consists of a brick arch provided with a vent leading to a 58-foot chimney stack. The bottom of the chamber consists of a fire brick floor laid on the top of a strong truck, the wheels of which roll in channels in the floor of the building. Mica glazed observation holes are provided in the walls so that all parts of the combustion chamber may be observed.

The furnace is heated by blast burners which discharge into the chamber on all sides through holes in the walls near the bottom, the flames being directed upward by baffle bricks. The burners are connected to the city gas mains and to the Laboratories' furnace blower system, suitable valves being provided for regulating the intensity and distribution of the fire.

Temperature Measurements. The temperatures in the furnace are measured with at least six thermo-couples so arranged as to indicate the temperature of the furnace gases at points about 2 inches from the center of each of the sides of the safe or cabinet under test. The temperature of the interior of the test sample is measured at a point in an upper front corner, in a diagonally opposite upper rear corner with thermo-couples, and in the upper central part with a recording thermometer. The thermo-couple wires and the connecting tube of the recording thermometer are conducted out of the test sample through a specially protected hole at the center of the bottom. The cold junctions of all of the thermo-couples are located in a common ice bath near the furnace and a cable leads from them to a switchboard and temperature measuring station about 30 feet distant. The indications of the thermo-couples are read with a portable potentiometer and those of the thermometer are recorded continuously on a round chart sheet.

Impact Test Apparatus. The apparatus used for Impact Tests consists of a stiff leg 4-ton derrick with 16-foot mast and 24-foot boom mounted on top of a 53-foot tower; of chain slings and a trip hook. The motive power for the derrick is a 4-ton double drum electric hoist.

The yard near the base of the tower is paved with smooth, continuous concrete extending from a large door of the building near the furnace to a heavily reinforced slab on which the safes are dropped. The slab is covered with a layer of brick rip rap about 6 inches deep.

Fire Stream Test Apparatus. The apparatus used in the Fire Stream Test consists of a special movable hydrant, or flexible nozzle attached to the hydrant, a gate valve for controlling the stream, and a pressure gauge attached to the base of the nozzle.

The hydrant is connected to the mains below the floor of the building and is supplied by the pressure tanks and an electrically driven pump in the plant.

Apparatus for Testing Materials. The apparatus used for tests upon materials includes a 200,000-pound Riehle testing machine, a 10,000-pound Olsen testing machine, balances special gas furnaces, electric furnaces, calorimeters and chemical test apparatus.

SECTION II

UNDERWRITERS' LABORATORIES' STANDARD METHODS OF EXAMINATIONS AND TESTS FOR SAFES AND INSULATED CABINETS

This section of the Standard treats of prescribed and standard examination and test procedures that are regularly employed by Underwriters' Laboratories to ascertain compliance with the standard of construction and performance under test given in Section III.

Plan of Investigation

Investigations of safes and insulated cabinets are made in accordance with the plan shown in the following outline, which indicates in the first column the separate phases or main divisions, in the second the various features involved in each phase, and in the third the titles of the tests and other means by which the information relative to each feature may be obtained. The procedure in the investigation of any individual type or pattern of safe or cabinet is to a considerable extent determined by its design and the character of materials used in its construction.

Information relative to any feature may be obtained from one or all of the sources indicated by the titles given in the third column of the outline mentioned, the extent of the investigation being largely determined by the results of the study of design and the character of the evidence obtained from the first tests and examinations.

Appendix XIII

DESIGN AND CONSTRUCTION	**Form and Arrangement of Parts**	Study of Design, Tests of Materials, Installation Tests, Operation Tests, Fire Test, Impact Test, Fire Stream Test, Examinations at Factory.
	Suitability of Materials	Study of Design, Tests of Materials, Operation Tests, Fire Test, Impact Test, Examinations at Factory, Service Record.
	Workmanship	Study of Design, Tests of Materials, Installation Tests, Operation Tests, Fire Test: Impact Test, Examinations at Factory, Field Inspections, Service Record.
PRACTICABILITY	**Handling and Shipping**	Study of Design, Installation Tests, Examinations at Factory, Field Inspections.
	Installation	Study of Design, Installation Tests, Field Inspections.
	Operation	Study of Design, Operation Tests, Field Inspections, Service Record.
	Maintenance	Study of Design, Operation Tests, Service Record.
DURABILITY	**Wear and Tear**	Study of Design, Tests of Materials, Installation Tests, Operation Tests, Field Inspections, Service Record.
	Swelling	Study of Design, Tests of Materials, Service Record.
	Corrosion	Study of Design, Tests of Materials, Fire Test, Service Record.
STRENGTH	**Strength of Parts**	Study of Design, Tests of Materials, Installation Tests, Operation Tests, Fire Test, Impact Test, Fire Stream Test, Field Inspections, Service Record.
	Strength of Assembled Device	Study of Design, Installation Tests, Operation Tests, Fire Test, Impact Test, Fire Stream Test, Field Inspections, Service Record.
FIRE RETARDANT PROPERTIES	**Heat Insulation**	Study of Design, Tests of Materials, Fire Test, Impact Test, Fire Stream Test, Service Record.
	Stability	Study of Design, Tests of Materials, Fire Test, Impact Test, Fire Stream Test, Service Record.
UNIFORMITY	**Uniformity of Parts**	Study of Design, Tests of Materials, Installation Tests, Operation Tests, Fire Test, Impact Test, Examinations at Factory.
	Uniformity of Assembled Device	Study of Design, Installation Tests, Examinations at Factory, Service Record.

The methods employed in conducting the tests and investigations are described in the following:

Study of Design. The safes or cabinets furnished for test, and the drawings and specifications submitted by the manufacturer are studied to ascertain the form and arrangement of the parts.

The safes or cabinets and the materials submitted are examined as to condition, quality and appearance to ascertain so far as possible by such means, the suitability of the materials for the purposes intended and to ascertain the probable character of the workmanship necessary in the materials and in the safes or cabinets in which they are incorporated.

The safes or cabinets submitted are examined for injury and defects and the drawings and specifications and the instructions for handling and shipping, installation and maintenance are studied to obtain information relative to the practicability of the methods advocated for handling and shipping; to obtain information relative to the practicability of installing the safes and cabinets in the situations for which they are advocated with the class of workmen to whom this work is intrusted; and to obtain information relative to the practicability of repairing the safes or cabinets under the various conditions likely to be met with in practice.

The form and arrangement of the parts are studied and the known properties of the materials considered with reference to the ability of the safes and cabinets to withstand the various deteriorating influences and the stresses to which they are likely to be subjected under service conditions.

The drawings and specifications of the safes and cabinets are studied and the known properties of the materials considered with reference to the probable degree of heat insulation and stability of the safes and cabinets under the fire exposures to which they are likely to be subjected in the classes of buildings for which they are advocated.

The materials submitted and the drawings and specifications are studied to ascertain the probable degree of uniformity with which the materials and the safes or cabinets can be furnished commercially.

The results obtained from the study of design are compared with the standard requirements given in Section III.

Tests of Materials. The materials used in the construction of safes and cabinets are subjected to separate examination and tests to ascertain their physical and chemical characteristics when the Laboratories is not in possession of the necessary information relative to their suitability for the purpose intended. These examinations and tests are confined to those that will furnish data that are pertinent to the various features of the investigation.

The results obtained in the tests of the materials are compared with the standard requirements given in Section III.

Installation Tests. The safes or cabinets submitted for test are handled, unloaded, unpacked and examined as received to obtain information relative to the practicability of handling and shipping advocated by the manufacturer, as evidenced by the facilities and number of men required in handling and the condition of the containers and any injury or breakage in the safes or cabinets.

The safes or cabinets submitted for test are moved over the cement floors at the Laboratories and are installed on substantial level foundations to obtain information relative to the practicability of the methods of installation advocated and the strength and rigidity of the finished product as evidenced by the facilities required to handle the safes or cabinets, the ease with which they can be moved and transported over the floor, the probable precautions necessary for the protection of the safes and the various floors likely to be met with in the field against injury, and consideration of the various sizes and weights of the safes or cabinets submitted.

The safes or cabinets submitted for test are then measured and examined relative to the workmanship and uniformity as evidenced by the accuracy of the fits and clearances between the parts, the finish and the uniformity of the dimensions. Steel plates, $\frac{1}{8}$ inch in thickness are then placed under diagonally opposite casters of the safes or cabinet to obtain information relative to the strength and rigidity of the assembled parts, as evidenced by any distortions in the parts or changes in the fits and clearances.

The safes or cabinets are afterwards moved to and from the furnace used for the Fire and Impact Tests and observations made similar to those mentioned.

The results obtained in the Installation Tests are compared with the standard requirements given in Section III.

Operation Tests. After the safes or cabinets submitted for test have been installed on their foundations at the Laboratories, the locking mechanism doors and any movable interior equipment of each is repeatedly operated while the safes or cabinets are supported on level foundations and after the plates have been installed under the casters. These tests are made to obtain information relative to the practicability of operation, the moving parts under conditions that may exist in the field, as evidenced by the ease with which they can be operated and the freedom from binding due to racking or improper fits and clearances.

The safes or cabinets are examined to ascertain the extent to which the doors will open, the suitability of the form and arrangement of and the materials in the operating parts, the accuracy of the fits and clearances between the moving parts, the practicability of making repairs and renewals of the parts, the probable ability of the operating parts to withstand the wear and tear and the stresses to which they are likely to be subjected, and with reference to the uniformity of the operating parts.

The results obtained in the Operating Tests are compared with the standard requirements given in Section III.

Fire Test No. 1. A medium size safe or cabinet submitted for test is subjected to a quick, hot fire in which all exterior surfaces of the test sample are exposed to fire and heat.

The safe or cabinet is placed on raised incombustible foundations in the bottom of a special test hut, the fuel placed in position in the hut, the heat measuring apparatus installed in the hut and connected, and the fire started.

The fuel is of such a character and so arranged that the temperatures surrounding the test sample rise to at least 1000 degrees Fahr. in $2\frac{1}{2}$ minutes, 1300 degrees in 4 minutes, 1500 degrees in $7\frac{1}{2}$ minutes, 1600 degrees in 10 minutes and 1700 degrees in 15 minutes. The test is continued for at least 30 minutes. The fire is then extinguished and the test sample allowed to cool.

Observations are made during the test of the general character, distribution and temperature of the fire, and of anything indicating the disruption of the parts or explosion of the test samples.

After the test sample has cooled to normal temperature, examinations are made covering any disruption of the parts or other indications of internal explosions, and covering its stability, as indicated by any bulging, buckling, warping, or separations.

Fire Test No. 2. The medium size safe or cabinet submitted for test is subjected to the standard fire conditions in which all exterior surfaces of the test sample are exposed to fire and heat.

The safe or cabinet is placed on the truck forming the bottom of the furnace, papers and records placed in the test sample, the heat measuring apparatus installed in the furnace and in the interior of the test sample adjusted and connected, the doors of the test sample and furnace closed and locked, and the fire started.

The gas and air supplies are adjusted so that the heat is well distributed throughout the combustion chamber and over the exposed faces of the test sample and so that the temperatures within the furnace rise to approximately 1550 degrees Fahrenheit during the first 30 minutes, to approximately 1700 degrees at 60 minutes, and gradually thereafter to the temperatures shown on the time temperature table given at the end of this chapter.

The test is continued until the highest of the temperatures indicated by the thermo-couples on the inside of the test sample reach 300 degrees. The fire is then extinguished and the test sample allowed to cool to normal temperatures without opening the furnace, the temperature in the interior being continuously recorded.

Observations are made throughout the test of the general character and distribution of the fire, the color of the parts of the test sample due to heat, the temperatures in the furnace and the temperatures in the interior of the test sample.

Observations are made throughout the test covering the heat insulation furnished, as evidenced by the temperatures recorded on the inside of the safe or cabinet and the time required for these temperatures to reach 300 degrees Fahrenheit; and also covering the stability of the safe or cabinet, as evidenced by any bulging, buckling or warping in or any sagging, separations, breakage or collapse of the parts, fusion or visible disintegration of the materials, or other evidence of insecurity or loss of strength.

After the safe or cabinet has cooled to normal temperatures, examinations are made covering its stability, as evidenced by any bulging, buckling, warping, or separations affecting the tightness of closure at the doors or between the parts; or by any breakage or bending of the parts or fusion or visible disintegration of the materials affecting the strength of or security of the fastenings between the parts.

The doors of the safe or cabinet are then forced open and examinations made covering the heat insulation, as evidenced by the legibility and usability of the records on the inside, the condition of the paint or enamel on the inside, and any other visible evidence of the transmission of heat; and also covering the stability of the safe or cabinet as evidenced by the security of the internal equipment, the locks, and the fastenings between the parts.

The safe or cabinet is then taken apart and examinations made covering the suitability of the form and arrangement of the parts for the purposes intended, the suitability of the materials and workmanship, the ability of the parts to resist corrosion, the strength of the parts and the assembled device, and the uniformity of the parts, as evidenced by the condition of the parts and the materials affecting the heat insulating properties and stability of the safe or cabinet.

The observations made during the period the safe or cabinet is exposed to fire, including all temperature readings, are regularly recorded at 5 minute intervals during the first hour and thereafter at intervals not exceeding 15 minutes.

The results obtained in the Fire Test are studied to ascertain compliance with the standard requirements given in Section III.

Table of Standard Furnace Temperatures

Time	*Temps.*	*Time*	*Temps.*
5 mins.	1000° F.	75 mins.	1750° F.
10 "	1300 "	90 "	1790 "
15 "	1400 "	105 "	1820 "
20 "	1460 "	120 "	1850 "
25 "	1510 "	135 "	1870 "
30 "	1550 "	150 "	1890 "
35 "	1580 "	165 "	1910 "
40 "	1610 "	180 "	1925 "
45 "	1640 "	195 "	1940 "
50 "	1660 "	210 "	1960 "
55 "	1680 "	225 "	1980 "
60 "	1700 "	240 "	2000 "

Impact Test. The large size safe submitted for test is subjected to the Standard Impact Test in which the safe is heated and dropped 30 feet in the clear on a rip rap of broken bricks.

The safe is first placed on the truck forming the bottom of the furnace, papers and records placed in the inside of the test sample, the heat measuring instruments installed in the furnace and connected, the doors of the test sample and furnace closed and locked and the fire started.

The test sample is exposed to the standard fire conditions for one hour, the observations during this period being the same as in the Fire Test except the temperatures in the interior of the safe are not measured. The furnace is then opened, the truck carrying the safe drawn out into the yard, and the safe immediately hoisted until the bottom is 30 feet above the rip rap of brick and dropped.

After the safe has cooled to normal temperatures, examinations are made covering its stability, as evidenced by any bulging, buckling, binding or separations affecting the tightness of closure at the doors or between the parts; or by any bending, breakage or collapse of the parts affecting the security of the fastenings between the parts or the strength of the assembled device.

The safe is then placed bottom upward on the truck, reinstalled in the test furnace and again subjected to the standard fire conditions for one hour, after which the safe is drawn from

the furnace and allowed to cool to normal temperatures. The observations during the period the safe is exposed to fire are the same as in the Fire Test, except that the temperatures in the interior of the safe are not measured.

After the safe has cooled to norma' temperature, examinations are again made covering its stability. The doors are then forced open and examination made covering the heat insulating properties, as evidenced by the legibility and usability of the records on the inside, the condition of the paint or enamel on the inside, and any other evidence of the transmission of heat; and also covering the stability of the safe as evidenced by the security of the internal equipment, the locks, the fastenings between the parts, and the condition of the parts.

The safe is then taken apart and examinations made similar to those at the end of the Fire Test.

The results obtained in the Impact Test are studied to ascertain compliance with the standard requirements given in Section III.

Fire Stream Test. When the results obtained in the Fire or Impact Tests are such as to indicate that the heat insulation or stability of the safe or insulated cabinet under investigation would be materially affected by the impact or contraction due to rapid cooling by fire streams, a medium size safe or cabinet is subjected to a Fire Stream Test in which the test sample is heated and then rapidly cooled by the application of a stream of water.

The safe or cabinet is exposed to standard fire conditions for at least one hour. The furnace is then opened, the truck carrying the test sample drawn out into the yard, and a 1⅛-inch stream of water immediately applied to the test sample for 5 minutes. The stream is directed against each of the sides from a distance of 30 feet, changes in the direction of the stream being made slowly. The pressure at the inlet to the nozzle is maintained at 50 pounds per square inch throughout the test.

The observations during the period the test sample is exposed to fire are the same as during the Fire Test, except that the temperatures on the inside of the test sample may not be measured.

Observations are made during and after the application of the stream covering the effect of the impact of the stream and the rapid cooling on the strength and stability of the safe, or cabinet as evidenced by bulging, buckling, warping, or bending of the parts, or breakage or lack of security in the fastenings between the parts.

The doors are then forced open and examinations made covering the effect of the stream on the heat insulating properties of the safe or cabinet, as evidenced by any separations at the doors or between the parts affecting the tightness of closure, or presence of water in the joints between the parts.

The results obtained in the Fire Stream Test are studied to ascertain compliance with the standard requirements given in Section III.

Examinations at Factory. The factory where the safes or insulated cabinets are manufactured is visited by Laboratories' engineers from the head office or nearest branch office for the purpose of obtaining general information regarding the manufacturer and the facilities provided for the manufacture of the safes or cabinets, and detailed information relating to those features of factory equipment and organization that have a bearing on the quality of materials employed, the character of the workmanship, the uniformity of the finished product, and the practicability of the methods of packing and shipping the finished product.

The materials are examined before and after the product is finished, to ascertain their uniformity and general suitability for the purposes for which they are intended.

The machinery and tools are inspected, the methods of manufacture studied, and the finished product examined to ascertain the accuracy with which the product is made and the degree of smoothness with which it is finished.

The facilities for checking the product for uniformity are examined in respect to their practicability and accuracy.

The method of packing the finished product for shipment is examined and studied with respect to its practicability.

The results obtained during the Examinations at the Factory are studied to ascertain compliance with the standard requirements given in Section III.

Field Inspections. If the safe or cabinet is being used commercially, inspections of actual installations in the field may be made by representatives of the Laboratories, preference being given to those installations most convenient to the main or branch offices.

These inspections include examinations to obtain information relative to the practicability of the methods employed in packing and shipping the safes or cabinets, as evidenced by their condition after they are received at the building; and examinations to obtain information relative to the practicability of installing the safes or cabinets, as evidenced by the facilities for such operations as hauling, handling, hoisting, transporting the safes or cabinets over the floors and installing them in position. The methods of installation advocated by the manufacturer are studied during these examinations.

The safes or cabinets are examined after installation with reference to the workmanship, as evidenced by the accuracy of the fits and clearances between the parts; with reference to the practicability of operating the moving parts, as evidenced by the ease with which these parts can be operated; and with reference to the strength and rigidity of the assembled parts, as evidenced by any binding between the moving parts due to distortions or changes in the fits and clearances.

When similar safes or cabinets have been in service in the buildings in which these inspections are made, investigation is made covering the character of service rendered during the period they have been in use. This investigation follows the procedure given under the title Service Record.

The results obtained during the Field Inspections are studied to ascertain compliance with the Standard requirements given in Section III.

Service Record. If the safe or cabinet has been used commercially for any considerable time, a list of purchasers is obtained from the manufacturer and letters sent to the users requesting information relative to the general suitability of the safe or cabinet for the purposes for which it was intended, and the character of the service it has given under the existing conditions.

Specific information is requested relative to the practicability of operating the movable parts; the practicability of making repairs or renewals; the ability of the safe or cabinet to withstand the wear and tear and deteriorating influences to which it has been subjected; its ability to withstand the stresses to which it has been subjected; and where several safes or

cabinets have been used, the degree of uniformity in the results obtained in service.

In case the safe or cabinet has been exposed to fire, specific information is requested regarding the intensity and duration of the fire to which it was exposed, its effectiveness in preventing loss of the contents, and the character and extent of the damage to the safe or cabinet.

The information obtained as a result of the investigation of the Service Record is studied in connection with the results of the other tests and investigations to ascertain compliance with the standard requirements given in Section III.

Report and Inspection Service Specifications. At the conclusion of the tests and investigations the report to the Fire Council of the Laboratories or the submittor is prepared. When the safe or cabinet has been found to comply with the requirements of the standard of construction and performance under tests for one or more of the classes given in Section III, and the Fire Council has concurred in the recommendations in the report, detailed specifications are prepared for use by inspectors assigned to conduct examinations under the Label Service.

SECTION III

UNDERWRITERS' LABORATORIES' CLASSIFICATION OF SAFES AND INSULATED CABINETS

Safes and Insulated Cabinets are classified according to their fire retardant and impact resistive properties as follows:

CLASS A *Includes safes that are effective against severe fires for at least four hours, and fairly heavy impacts from falling or from falling bodies.*

CLASS B *Includes safes that are effective against severe fires for at least two hours, and fairly heavy impacts from falling or from falling bodies.*

CLASS C *Includes safes that are effective against severe fires for at least one hour, and fairly heavy impacts from falling or from falling bodies.*

INSULATED CABINETS *Includes cabinets that are effective against fires of moderate severity for at least 45 minutes, and that are not subject to impacts from falling or from falling bodies.*

Underwriters' Laboratories' Standard of Construction and Performance Under Tests for Safes and Insulated Cabinets

Safes and Insulated Cabinets complying with the following requirements are entitled to classification as standard in their respective classes.

Safes and Insulated Cabinets embodying forms of construction other than those indicated in this section are examined and tested under the standard and, if found to give equivalent results, receive recognition accordingly.

Design and Construction: (*a*) To embody insulated walls and doors, substantial hinges and locking mechanism, substantial casters, wheels or base and suitable internal equipment for the contents.

(*b*) The form and arrangement of the parts and the materials to be such that the parts and the assembled safes or cabinets will be practicable, durable, capable of safely withstanding the stresses and exposure to fire to which they are subject in the class of service for which they are advocated, and capable of being uniformly manufactured in commercial quantities.

(*c*) The parts to be formed, assembled and finished with the degree of accuracy, precision and uniformity necessary to furnish the requisite properties for safes or cabinets of good, reliable quality for the class of service for which they are advocated.

Practicability: (*a*) Safes or cabinets to be so designed and constructed that they can be handled, transported and installed, without serious injury, by the class of workmen to whom this work is ordinarily intrusted.

(*b*) Safes or cabinets to be so designed and constructed that the doors, locking mechanism and other movable parts can be reliably operated without undue effort by those to whom the operation of such devices is ordinarily intrusted.

(*c*) Safes or cabinets to be so designed and constructed that the doors, locking mechanism, interior equipment and other movable parts can be repaired or renewed, but not necessarily by those unskilled in such devices.

Durability: (*a*) Safes or cabinets to be so designed and constructed that they will withstand without material deterioration for indefinitely long periods the wear and tear of ordinary use.

(*b*) Safes or cabinets to be so designed, constructed and protected that they will withstand without material deterioration for indefinitely long periods the inside and outside corrosive influences to which they are subject in the class of service for which they are advocated.

(*c*) Heat insulating materials used in safes or cabinets to be free from sweating or swelling and capable of retaining their heat insulating properties for indefinitely long periods.

Strength: (*a*) The parts and the assembled safe or cabinet to be sufficiently strong and rigid to withstand the stresses to which they are subject during handling, shipping and installation without material injury or the development of distortions or changes in the fits and clearances that will materially affect the strength of the assembled device or the reliability of operation of the movable parts.

(*b*) The parts and the assembled safe or cabinet to be sufficiently strong and rigid to withstand the stresses to which they are subject when the movable parts are repeatedly operated, without the development of distortions or changes in the fits and clearances that will materially affect the reliability of operation of the movable parts.

(*c*) The parts and the assembled safe or cabinet to be so designed and constructed that they will withstand the stresses occasioned by the Fire Test for the respective classes without bulging, buckling, warping, fusion, disintegration or other developments that will vitally affect the security of the locks and fastenings between the parts, or the strength of the parts or the assembled safe or cabinet.

(*d*) The parts and the assembled safe or cabinet to be so designed and constructed that they will withstand the stresses occasioned by the Fire Stream Test without bulging, buckling, warping or other developments that will vitally affect the security of the locks and fastenings between the parts, or the strength of the parts or the assembled safe or cabinet.

(*e*) The parts and the assembled safe to be so designed and constructed that they will withstand the stresses occasioned by the Impact Test without bending, distortions, displacements, ruptures or other developments that will vitally affect the security of the locks and fastenings between the parts, or the strength of the parts or the assembled safe.

Fire Retardant Properties: (*a*) The different classes of safes and the insulated cabinets to withstand the Standard Fire Test for the following periods before the highest indicated internal temperature reaches 300 degrees Fahrenheit, without destroying the legibility of the records stored on the inside, and without the development of separations or temperature effects on the inside or disintegration of the parts or materials that clearly indicate conditions likely to vitally affect the tightness of closure or the heat insulating properties of the safe or cabinet.

Class A Safes at least 4 hours,
Class B Safes at least 2 hours,
Class C Safes at least 1 hour,
Insulated Cabinets at least ½ hour.

(*b*) All classes of safes to withstand the Standard Impact Test without destroying the usability of the records stored on the inside, and without the development of temperature effects on the inside, separations, distortions, displacements, ruptures or other developments that clearly indicate conditions likely to vitally affect the tightness of closure or the heat insulating properties of the safe.

(*c*) All classes of safes, and insulated cabinets, to be capable of withstanding the Standard Fire Stream Test without destroying the usability of the records stored on the inside, and without the development of temperature effects on the inside, or structural weakness that clearly indicate conditions likely to vitally affect the tightness of closure or the heat insulating properties of the safe or cabinet.

Uniformity: The parts and the finished safes or cabinets to be so designed that they can be made in commercial quantities with a sufficient degree of uniformity to prevent any material variation in their ease of operation, durability, strength, and fire retardant properties.

SECTION IV

GENERAL DESCRIPTION OF THE LABEL SERVICE PROCEDURE

This section of the Standard treats of features of the Label Service form of follow-up which, except for minor modifications, are common to all industries utilizing the Service.

Underwriters' Laboratories' Label Service as Applied Generally to All Industries

Purpose of the Label Service. The Label Service is designed to provide a means whereby materials, classified as standard by the Laboratories as the result of examination and test of samples, are so constructed that the specified standards of quality and performance are maintained for product placed on the market and whereby such product may be readily identified by purchasers, property owners, inspection authorities and others interested.

Scope of the Label Service. The Label Service consists of:

(*a*) Factory Inspection Work:—Inspections of Products at factories and the labeling of standard product.

And in addition where practicable, of

(*b*) Field Follow-up Work:—Check tests on labeled product when reviewed where installed.

(*c*) Schedule Estimates:—Showing comparative demerits noted on labeled products.

Experience has shown that the Label Service is in every way superior for the purpose of

bringing to the consumer the article he desires, for the purpose of placing competition between manufacturers beyond the point where deterioration in the quality of the output is made necessary, and for the proper protection of the Laboratories and the organizations co-operating with it which are giving substantial recognition to efficient fire protection and accident prevention appliances.

It has also been shown that an inspection and checking system of this nature can be efficiently operated under the Laboratories' direction without calling upon the manufacturer to give undue publicity to his manufacturing processes or subjecting him to embarrassment or annoyance.

Labeled products are not necessarily uniform in quality or merit. Labeling indicates only compliance with the Standards of the Laboratories for the product.

The Factory Inspection Work. The purpose of the Factory Inspection Work is to make examinations and tests at factories of material prepared for the market and to supervise the use of labels on the product.

Labels are applied at the factory by the manufacturer, to such of his output as conforms in all respects to the Standards of the Laboratories for the product, as shown by his own examination and tests, subject to the results of the examination and tests made by the inspector. The label thus serves as evidence of proper construction of the goods at the factory.

An inspector appointed by Underwriters' Laboratories visits the factory as often as occasion demands for the purpose of making examination of material prepared for shipment and making supplementary tests as outlined in the Standards of the Laboratories for the product.

Necessary Co-operation from Manufacturers in Factory Inspection Work. The low cost at which the Label Service is carried on makes it apparent that the fullest measure of co-operation is essential on the part of the manufacturer in instructing his employees to construct for labeling none other than duplicates of the standard sample. The Service is principally designed to serve as a formal check on the Supervision which the manufacturer exercises over the character and quality of his output. It is not designed to relieve the manufacturer of responsibility and cannot be utilized in cases where the desire for earnest co-operation is not manifest.

The Procedure in the Factory Inspection Work for the product covered by these Standards is given in Section V following.

Appeals on Standards and Conclusions Based Thereon

Courses of Appeal. Underwriters' Laboratories aims to secure the best and fairest opinion with respect to the merits of appliances, devices and materials submitted for its review and to have its work so carried on as to insure accuracy and uniformity in its findings. One of the measures adopted to assist in accomplishing these aims is the provision made for appeals from its findings by any client who may feel that the conclusions reached by the Laboratories as the result of either the original examination and test for listing, or the subsequent examinations and tests in the Inspection Service, or other methods of follow-up fail to give full recognition to the claims made for the appliance, device or material, in-so-far as these relate to the fire or accident hazard, or that the Standards, test methods or procedure are incorrect, or that the methods and practices in the conduct of the Service are lacking in efficiency, integrity or good faith.

National Bureau of Standards of the Department of Commerce. Where the question involved relates to the correctness of test methods and procedures and the conclusions based thereon, or has to do with similar features of the conduct of the technical work, an appeal may be taken to the National Bureau of Standards of the Department of Commerce at Washington, D. C. There exists a permanent arrangement between the Bureau of Standards and Underwriters' Laboratories whereby the Bureau consents to act on such appeals and whereby the Laboratories agrees in advance to accept the decision of the Bureau as to the correctness of its findings on these technical matters.

Industry Conferences. For a number of industries, conferences are established consisting of the proper members of the Laboratories Staff and representative committees of manufacturers to the end that full information as to examination and test methods may be transmitted to industries served by the Inspection Service and the views of the industry as a whole on such items be secured. The manufacturers' representatives on such industry conferences are usually nominated by the manufacturers through their associations, when such exist. Such a conference has referred to it by the Laboratories or by any individual manufacturer in the industry employing the Inspection Service, questions relating to the Standards under which the service is carried on, and exercises a general supervision over the Service for the industry it represents. The business of such a Conference is transacted by correspondence and by meetings held from time to time.

Appeals in Case of Disagreement. The practices and procedure in the conduct of the Inspection Service are defined for each individual industry in the Standards of the Laboratories for the product.

The agents of Underwriters' Laboratories at its several branch offices are authorized to pass as standard devices or materials found as the result of their inspections at factories to be in conformity with the requirements of the Standards and the description in the Laboratories record.

In case the manufacturer judges that authorization should be given for other standard goods examined, he should proceed as follows:

Appeal to Underwriters' Laboratories.

1. The manufacturer should immediately advise the Superintendent of the Label Service at the principal office of the Laboratories at Chicago (Preferably by telegraph). Promptly following the receipt of such advices, the Laboratories will send a Special Agent or one of its head office engineers to the manufacturer's plant to adjust the matter.

2. In case the Special Agent, head office engineer, or the Superintendent of Label Service is unable to satisfy the manufacturer in the matter of his complaint, the manufacturer should then lay the matter in writing before the President of the Laboratories.

3a. In case this does not bring a satisfactory adjustment, a further appeal may without delay, be made to the Board of Directors of the Laboratories, or as an alternative:

Appeal to a Board of Arbitration. *3b.* Where the question at issue does not involve changes in adopted Standards, but concerns the competency of officers, agents, or employees of either party, or the methods employed by them to the detriment of the other, as follows:

(*w*) Unnecessary delays or negligence.
1. By the Laboratories in making inspections.
2. By the Manufacturer in correcting admitted defects, or in providing and using suitable testing appliances.

(*x*) Lack of integrity or of good faith by either party.

(*y*) Ignorance by either party of Standards accepted by the Laboratories and the manufacturer.

(*z*) Prejudice or favoritism by either party.

It is optional with the manufacturer or with the Laboratories to elect in place of "3a" to have charges of the nature of those described above (not involving changes in adopted Standards) passed upon by a Board of Arbitration made up of three members, as follows:

One member to be chosen by the Manufacturer.

One member to be chosen by the Laboratories.

These two to choose the third.

The decision of this Board of Arbitration on the question of competency or conduct of the officers, agents or employees shall be final, the party against whom the decision is given shall pay the costs of the Board, and where lack of competency or improper conduct is shown, the servant or servants responsible therefor shall be reprimanded or discharged.

Whenever the finding is against Underwriters' Laboratories and Label Service has been suspended at the manufacturer's plant it shall be immediately resumed if desired by him.

Whenever the finding is against the manufacturer, Label Service will be resumed when the conditions which have been complained of are corrected by the manufacturer in a manner permitting proper operation of the service.

Appeal to Industry Conference. *3c.* Questions of general interest to the industry as a whole and having to do with the Laboratories activities in the field of the industry may be brought for consideration to the Industry Conference. The Industry Conference is ready to serve as a Board of Arbitration on questions which may arise in the conduct of the Factory Inspection Work and either the manufacturer or the Laboratories may elect to refer questions at issue to the Conference rather than to a Board of Arbitration selected as previously described.

Label Service

Cost of the Label Service. The cost of the Label Service is defrayed by charges made for the labels. These charges vary according to the nature and extent of the inspection needed. For goods which can be tested by machinery or which are machine made and run through factories in such quantities that tests of a number of samples of each day's output give a fair criterion of the whole product, the charges run from fifty cents ($0.50) to one dollar and a half ($1.50) per thousand labels. For goods made by hand and goods which require inspection or test of each individual device, the charges run from seven and one-half cents ($0.07½) to fifty cents ($0.50) per label. In no case is the cost of the Service as represented by the charge for the label sufficient to become a factor of importance in determining the selling price of the article labeled.

The cost of labels for the product which is the subject of this Standard is as given in Section III following. The price charged for the labels covers the following costs:

1. The cost of making and handling the labels.
2. Time and carfares of inspectors at factories.
3. Proportionate part of the following costs:
   w. Special Agent Work.
   x. Home office supervision of conduct of Label Service.
   y. Countercheck testing and research work.
   z. Overhead charges.

Regular Service. The names of manufacturers regularly employing the Label Service in each separate industry are carried in the records of the Laboratories, and all such manufacturers are freely consulted in all matters concerning Standards of construction and inspection of the product of that industry.

In order that the Laboratories may maintain an efficient inspection and the requisite familiarity with the affairs of each industry it is necessary that they be assured a minimum amount from the yearly use of labels by each manufacturer.

The cost of the Label Service in each separate industry is based upon the expectation that the payments of each manufacturer included in the industry list will aggregate at least Thrity-six Dollars ($36.00) for each calendar year. If the amount paid for labels during a calendar year shall be less than Thirty-six Dollars ($36.00) the manufacturer is required to make up the difference between said Thirty-six Dollars ($36.00) and the sums already paid in during the year for such labels.

The minimum "Ready to Serve" charge of Thirty-six Dollars per year is calculated to cover participation in the Laboratories' dealings with the industry, and the cost of a necessary minimum number of inspections, where few, if any, labels are used.

Underwriters' Laboratories is for service, not profit, and charges for this Service only the actual cost thereof. Label prices are from time to time adjusted accordingly.

Limited Service. A manufacturer who does not care to participate in the Laboratories' dealings with an industry (including carrying his name in the records, consultation on Standard, etc.) and who anticipates using each year less than Thirty-six Dollars ($36.00) worth of labels, may obtain inspections of and labels for a single article or small lot of the article at such rates as will cover the Laboratories cost for the service rendered in each case.

The basis of charge for the Service shall be a function of the cost of such service under the specific conditions rendered within reasonable limits and shall be paid by the manufacturer within thirty (30) days after the rendering of bills for such service by the Laboratories. A reasonable basis of charge for Service is hereby defined to be as a rate of two dollars ($2.00) per hour per man, calculated according to the number of hours which in the judgment of the Laboratories were necessarily spent in the inspection work at the factory and in addition the time and other expenses of the inspector for traveling to and from the factory together with the cost of countercheck tests made at a testing station of the Laboratories, when such tests

are called for in the Procedure. In addition the usual charge for labels will apply when labels are delivered.

Such Limited Service is, of course, available only after the manufacturer's device or material has been reviewed by the Laboratories and has been classified according to the same procedure and under the same Standards as apply to similar products under the Regular Service.

Serial Numbers on Labels. The serial numbers on the labels are for the purpose of countercheck by the Laboratories. A record is kept, by means of these numbers, of the manufacturer to whom they are issued, the date of issue and the approximate date of use. It is not required that manufacturers shall keep record of these serial numbers.

Use of Labels in the Order of Their Serial Numbers. Manufacturers are urged to use the labels in the consecutive order of their serial numbers so far as is possible.

Deliveries and Use of Labels. Stocks of labels are kept at each of the several Branch Offices of Underwriters' Laboratories. Labels will be delivered from these stocks to factories located within the territory of the Branch Office promptly following receipt of order stating the number of labels desired. Payment for labels is to be in advance in all cases, and orders for labels should be accompanied by remittances drawn payable to UNDERWRITERS' LABORATORIES.

Labels will be supplied from the nearest office of the Underwriters' Laboratories, which in the case of the manufacturer indicated on the front page of these Standards, is.....

In order that proper supervision of the use of labels may be had by Underwriters' Laboratories through its authorized inspector, it is required that labels be applied to products only *in the factory* in which the products are made and *before shipment* from the factory. The cost of the Label Service (covered by the price charged for the labels) does not anticipate supervision of the labeling of the product at other than the factory (*i.e.*, not in manufacturer's, jobber's or dealers' warehouses, etc.) and labels so used will not be recognized and when found will be cancelled and inspection authorities and others so notified. Similarly, deliveries of labels by one factory to another whether under common management or not, will result in special conditions being established with regard to future use of labels in either plant.

Use of Name of Underwriters' Laboratories. Manufacturers shall not make use of the name of the Laboratories or an abbreviation, symbol or any equivalent thereof (other than that which appears on the Label itself) on products provided, however, that subject to the approval of the Laboratories as to wording and method of attachment the manufacturer may refer, on the package, carton or other container in which the product bearing the inspection label is packed for shipment or sale to the fact that the original contents of the package, carton or other container bears the Laboratories' inspection label.

The label is evidence of inspection at the factory in which the products are made. We do not permit subscribers to furnish labels for attachment in the field either by themselves or by their customers. Violation of the foregoing rules will result in suspension of label service and the institution of special conditions regarding their future use.

SECTION V

PROCEDURE FOR INSPECTION AT FACTORIES AND THE USE OF LABELS ON SAFES (CLASS)

Labels for Safes (Class)

Design:—The labels for CLASS SAFES are of etched brass and are ⅝-in. wide by 3¼ inches long. They are of the general appearance and design as shown below

Underwriters' Laboratories INSPECTED SAFE Class____ No.____

Labels as issued are serially numbered. The labels are furnished in packages of 100 labels each and are provided with two 1-16 in. holes for attaching, holes being spaced 3-1-16 in. on centers.

Application of Labels:—The labels are secured to the device by at least two rivets or screws with heads headed over after attaching, where they will be visible. One label is used for each safe, and they are applied by the manufacturer to such of his product as is judged to conform to the foregoing specifications.

Price Charged for Labels:—The price of labels for SAFES CLASS is now $50.00 per 100 labels.

Privileges of Inspectors. The inspector shall have free access, during hours in which the factory is in operation, to the test room, assigned to his use, and to store or shipping rooms for finished labeled products. It will be his privilege to inspect and subject to prescribed examinations and tests, prior to shipment, any or all product which is labeled or which is intended to be labeled; and the manufacturers must grant to him all necessary rights and privileges and provide all necessary appliances and assistance for such purpose.

General Instructions to Inspectors

Conduct at Factory. The inspector shall refrain from conversing with any employee of the manufacturer other than the person or persons designated by the manufacturer to receive his comments. The inspector will avoid entering any portion of the factory where

the necessities of his work do not require his presence.

Correspondence. Copies of all letters from the manufacturer to the Inspector must be promptly forwarded to the Laboratories.

Labels. The inspector shall see that the use of labels is confined to product complying with the Specifications of the Standards and with the Description of the product of the manufacturer. The inspector is not authorized to allow labels to be used on any product not covered by the Description, except as the result of special advice to him and to the manufacturer from the Chicago testing station of the Laboratories.

Duties of Inspectors. The inspector's principal duty is to satisfy himself that all products shipped from the factory with the label attached, conforms in all essentials with the Specifications of the Standards and with the Description for the product of the manufacturer. It will usually be the case that the manufacturer's program of production, inspection, test and shipping is well known to the inspector, and may be regarded as largely assuring uniformity of output from day to day. Hence, under normal conditions the inspector's work will be that of counter checking, the product already passed by the manufacturer as suitable for labeling. When and while these conditions do not obtain, the inspector may be advised by the Superintendent of Label Service as to the special procedure to be followed.

Inspectors' Reports

General. The inspector will report on form on yellow paper, like sample following, the results of examinations and tests made by him at each factory inspection. Under normal conditions copies of this report will not be furnished to the manufacturer by the inspector. It shall be understood, however, that test results shall become a part of the manufacturer's permanent test record.

A report must be made out for each inspection as soon as possible after a visit to the factory and be promptly forwarded to the Chicago Office for review.

The inspector will clearly indicate in reports all sub-standard features developed in the examination or tests. Criticisms or suggestions made by the inspector to the manufacturer shall be in writing and if given orally shall be confirmed *at once* in writing in all cases. For all such confirmations form L.S. Genl. 1 on pink paper like the sample following shall be employed.

Filling in Report Forms

First Page of Report Form. Fill in completely as indicated.

"Ref. No." refers to the Laboratories classification (the letters E., R., Ex., MH., etc., are used to denote "Electrical," "Retardant," "Extinguisher," "Miscellaneous Hazard," etc., under which the product is listed by the Laboratories and to the file number of the Laboratories record on the construction and tests of the original samples.

"Serial No." refers to the number of the inspection or report in the numerical order of the inspections and reports which have been made at this factory during a given year on the product covered by these Standards.

Always fill in the date on which the inspection was made and give the name and address of the manufacturer in full.

Under "Criticisms" give a summary (in the form of a carbon copy of the "notice of defects" letter to the manufacturer) of the sub-standard features, including, if any, failures in tests noted in the detailed examinations and tests in the inspection being reported upon. These features are to be noted also under the individual headings on the other pages of the report form.

Fill in blank spaces under this heading as indicated.

All criticisms must be reported immediately and in writing to the factory management, using the special pink paper form, L.S. Genl. 1 or "Notice of Defects" provided for the purpose. When using this form the inspector shall arrange that a carbon copy of the advices given thereon shall be made on the regular report form under the heading "Criticisms." The spacings on the form are arranged so that this may be done readily.

Under "Summary of Tests and Failures" the inspector shall give the number of tests made and the number of failures obtained in the inspection being reported upon.

Under "Labels" give the information called for. The serial number of the labels are to be given also under the individual headings on the other pages of the report form.

Under "General Remarks and Recommendations" the inspector may advise as to his general impressions of the progress of the inspection work at this factory and any items of general interest. When criticisms are made, he should briefly state whatever suggestions or recommendations he may have as to the way the situation should be handled, supplementing the same usually by letter or telegram. If he has, himself, taken any action the report should so indicate. The inspector should advise briefly of improvements made in features criticised in this or previous reports and of general improvements in the workmanship of the material and in the arrangement and character of test apparatus, etc.

"Signature"—The report should be signed by the inspector making the inspection and the name of the branch office at which he is stationed should be given together with the time and carfare charged for the inspection.

Other Pages of the Report Form. The inspector shall fill in the form as indicated with the data secured as a result of examinations and tests upon product reviewed by him on the date of the inspection being reported upon.

Inspectors must always fill in forms with all of the information asked for if it has been obtained. A dash or blank in report form is understood to indicate that the inspector has no information to furnish on the point in question. When possible, answer briefly by "Yes" or "No" or "O.K." or by the figures or other data called for.

The information given by the inspector on the report form should usually be only that obtained on the date of the report and usually only that obtained as a result of examination of the devices being reported upon. In some instances it is desirable, however, that stocks of materials held by the manufacturer and intended for use in the construction of labeled devices shall be gone over, especially as new supplies are received. If the information given is the result of observation of stocks of materials not yet assembled the inspector should make a statement to that effect on the report form.

Sub-standard features are to be noted also on the first page of the report form under "Criticisms."

Form L. S. Gen'l; sold out

Report from Branch Office in

City

By

(Signature of Inspector)

Date of Insp. Ref. No. Ser. No. of Rep.

Charges For This Inspection

	ITEMS		TOTALS	
Postage on Samples				
Hotel (Out of Town)				
Car Fare				
Time	Hrs			
		Total		

Labels

Serial Nos. of labels used since last previous inspection

Unsoon	From	To	Total

Are labels used in order of Ser. Nos.?

Ser. Nos. of labels removed from rejected product?

Die Label of form and size specified?

Was it located as specified?

Was wording legible?

Summary of Tests and Failures

DETAIL	No. of Samples Inspected	No. of Samples Substandard

Samples to Chicago Office

How Shipped { ——Exp. / Parcel Post } { Prepaid / Collect }

Date on which last previous samples were selected?

INSULATED CABINETS (72)
LIGHT WEIGHT SAFE

Manufacturer
Name of

Factory
Location of

UNDERWRITERS' LABORATORIES

POSTING CHECK

FACTORY INSPECTION REPORT

LABEL SERVICE WORK

EXAMINER'S CHECK

Criticisms. Were all the details marked on the other pages of this report checked by you on product inspected on this date? Were substandard features noted in any samples?

To whom were the criticisms orally reported?

Was the oral report confirmed on "defect notices" to manufacturer?
(A carbon copy of the summary of substandard features as listed on the "defect notice" should be given herewith.)

General Remarks and Recommendations Were substandard features corrected on all samples? Or were labels removed? If not, explain action taken.
Use telegraph whenever there is urgent need for prompt action by the Chicago Office.

SUMMARY POSTING CHECK

First page of Factory Inspection Report

Form 72

INSULATED CABINET LIGHT WEIGHT SAFE

	Ins. Cab.	Light Weight Safes		
		A	B	C
SIZES				
Were the sizes examined within the limits specified? width				
depth				
height				
area of walls				
length of door joints				
MECHANICAL CONSTRUCTION				
Thickness of sheet steel? (Thousandth inches) outer shell				
inner shell				
doors				
Are sections formed as specified? outer shell				
inner shell				
doors				
Are sections reinforced as specified? outer shell				
inner shell				
doors				
Are jambs, sill, and lintel sections form and dimen. spec.?				
Are stile and rail sections of doors of form and dimen. spec.?				
Are these sections reinforced as spec. at holes for latch bars?				
Are all sections secured to each other as spec.?. outer shell				
inner shell				
doors				
Is inner shell secured to outer shell as specified?				
Are walls of body of the thickness specified? back				
sides				
top				
bottom				
Are walls of doors of the thickness specified?				
Are caps, if any, formed as specified?				
Are caps, and moldings, if any, secured as specified?				
Are doors supplied in pairs as specified?				
Are special features, if any, provided as specified? (See supplementary sheet)				
HEAT INSULATION				
Is composition of the insulation as specified?				
Is the thickness of the insulation as specified? sides				
top				
bottom				
back				
doors				
Is the insulation free from excess moisture?				
Is the insulation secured in place as specified? sides				
top				
bottom				
back				
doors				

Second page of Factory Inspection Report

	Ins. Cab.	Light Weight Safes		
		A	B	C
Is the insulation reinforced as specified? (body)				
Is the insulation free from objectionable defects? (doors)				
Is the insulation of the walls as complete as required? (body)				
Are the joints between sections of insulation made tight and as specified? (doors)				
HARDWARE				
Hinges				
Are these of the material specified?				
Are they of the form and dimensions specified?				
Are they spaced as specified?				
Are they secured to body and doors as specified?				
Latching Mechanism				
Are the latch bars of the form and dimen. spec.?				
Is operating mech. for single doors of form and dimen. spec.?				
Is operating mech. for "standing" doors of form and dimen. spec.?				
Is operating mech. for "swinging" doors of form and dimen. spec.?				
Are latching mech. secured to doors as spec.?				
Do latch bars project at least ¾-inch from door edges?				
Locks				
Are combination and key locks, when used of design spec.?				
Are they secured to doors as specified?				
Casters				
Are these of the material specified?				
Are they of the form and dimensions spec.?				
Are they spaced as specified?				
Are they secured to body as specified?				
FINISH				
How is metal protected against corrosion?				
INTERIOR FITTINGS				
Are supports for shelving, partitions, etc., when provided made and attached to inner shell as specified?				
WORKMANSHIP				
Comment on workmanship as shown by:				
Completeness of insulation of shells				
Fit of sections of inner shell				
Effectiveness of riveting and welding operations				
Ease of operation of latching mechanism				
Fit of latch bars in catches				
Fit of doors with body on face and at rabbets				
MARKINGS				
Is each finished cabinet and safe marked with the name or trade mark of the manufacturer?				

Third page of Factory Inspection Report

W H MERRILL, President
W C ROBINSON
DANA PIERCE } Vice Presidents
A R SMALL
D B ANDERSON, Secretary
L B READER, Treasurer

CHICAGO, 207 E. OHIO ST.
NEW YORK, 25 CITY HALL PLACE
BOSTON, 87 MILK ST.
PITTSBURGH, 324 FOURTH AVE.
AGENCIES IN ALL PRINCIPAL CITIES OF THE UNITED STATES AND CANADA

Underwriters' Laboratories

INCORPORATED 1901
ESTABLISHED AND MAINTAINED BY THE
National Board of Fire Underwriters
FOR SERVICE—NOT PROFIT

207 EAST OHIO STREET, CHICAGO

LABEL SERVICE WORK

NOTICE OF DEFECTS

FACTORY INSPECTION

Date_____ 19__ Ref. No._____ Serial No._____
(When inspection was made) (Of this report)

Manufacturer_____
Name of

Factory_____
Location of

Attention of: _____ 19__
(Date of Notice)

_____
(Name of Officer and Title)

Gentlemen:

Inspection at your factory on above date developed sub-standard features in product submitted for labeling as noted below.

Copy of this letter has been forwarded to Chicago Office on inspection report of above serial number.

This confirms oral advices given to Mr._____

UNDERWRITERS' LABORATORIES

From Branch Office in_____ by_____
(City) (Name of Inspector)

Official notice of sub-standard features

Appendix XIII

Procedure in Factory Inspection Work

Definitions. *Specifications.* The term "Specifications" as used in this Procedure refers to the Specifications given in Section I (of the Procedure for each manufacturer).

Standard Sample. The term "Standard Sample" or "Description" as used in this Procedure refers to a duplicate of the sample of the manufacturer's product which was tested by Underwriters' Laboratories, and which forms the basis upon which the product of the manufacturer is listed by the Laboratories as being in compliance with the Specifications for the product.

The standard Sample, when one is used, is in duplicate; one sample being filed at the Chicago Office of the Laboratories and the other filed with the Branch Office assigned to conduct the Factory Inspection Work on the product.

Scope of Factory Inspection Work. The Factory Inspection Work consists of checking essential features of construction and design of representative samples, with a duplicate of the original sample tested. It includes:—examinations of materials used and of workmanship; measurement of dimensions of materials; checking of form and arrangement of parts; operating tests of finished product, etc.

Under usual conditions every detail of the Description or Standard Sample shall be checked by the inspector at each inspection. It will not usually be practical, however, nor should it be necessary for the inspector to check each device in all of the particulars given in the Description and Specifications or shown by the Standard Sample. For example, one device may be examined in certain details, another in others, etc.

If any deficiencies are found, it will be necessary for the inspector to either reject the whole lot, or to subject each device to a complete examination and reject those devices which are deficient for labeling. The course to pursue in such cases will usually be indicated by the circumstances. The inspector shall require that each device be made standard if it is to retain the label and he should watch carefully for a recurrence of a like deficiency in devices made subsequently until the product appears to be again normal.

The following detailed procedure for conducting the Factory Inspection Work together with the following requirements for performance of the product under examinations and the following details of construction shall apply.

Examination and Test Methods. The following is to be regarded as instructions covering the application of the specifications to this Factory Inspection Work. The Specifications are supplemented in the following by additional matter to be regarded as instructions covering the application of the Specifications to this Factory Inspection Work.

Second and Succeeding Pages. The Laboratories inspector will not accept for labeling, fire-resisting storage receptacles of other classifications than those given in the Specifications ***i.e.,*** if only receptacles of the Insulated Cabinet classification are described in the Specifications, the inspector will not permit the labeling of receptacles of the Light Weight Safe classification.

The Laboratories inspector will not combine on one form, a report covering inspections of both Insulated Cabinets and Light Weight Safes but will render two reports using a separate form for fire-resisting storage receptacles of each classification.

Sizes. Storage receptacles of sizes exceeding the limitations given in the Specifications are not to be accepted for labeling. It should be noted that the sizes are limited in four ways: inside width, inside depth, inside height, area of inside walls, and length of door joints on inside of cabinet or safe (*i.e.* perimeters of doors, including perimeters of both doors when doors in pairs are used, the joint between doors in pairs to be measured but once).

Mechanical Construction. The inspector will not accept for labeling, storage receptacles having any sections, outer shells, inner shells or doors made of sheet steel of lesser nominal thicknesses than those given in the Specifications. Metal nominally of the following U. S. gauges should measure:—

U. S. Gauge No.	*Nominal Thickness—inches*
24	0.025
22	0.03125
20	0.0375
18	0.050
16	0.0625
14	0.078

To allow for mill variations, stock not less than the following:—

U. S. Gauge No.	*Minimum Thickness—inches*
24	0.0235
22	0.0295
20	0.0355
18	0.0475
16	0.0595
14	0.0740

may be used in the construction of storage receptacles but the inspector should not be expected to accept a lot of storage receptacles made from stock all of which is of this minimum thickness since the usual mill run of this material should average up to gauge. The thickness of a sheet of metal is to be taken as the average of at least five measurements across the width of the piece. Decreases in thickness due to the drawing of the metal in presses or brakes may be disregarded. Measurements for thickness of sheet shall be made with round-nosed micrometer calipers reading directly in thousandth inches.

The inspector will not accept for labeling, storage receptacles having any sections of the body (including joints, sill and lintel sections) or doors (including stile and rail sections) formed of materials or of a design other than is given in the Specifications.

The inspector will accept for labeling only such storage receptacles as have all sections of inner shells and doors reinforced to stiffen the sections and to provide for attachment of hardware as required in the Specifications. The reinforcements must be secured in place as specified.

The inspector will not accept for labeling storage receptacles, having joints, sill and lintel sections of body, and stile and rail sections of doors reinforced for latch bars in a manner other than is given in the Specifications.

The inspector will not accept for labeling, storage receptacles having the several sections of the outer shell, inner shell or doors secured to each other in a manner other than is given in the Specifications.

The inspector will not accept for labeling, storage receptacles having inner shells of body secured to outer shells in a manner other than is given in the Specifications.

The inspector will not accept for labeling, storage receptacles having bodies or doors with

any wall of a thickness other than is given in the Specifications. The thickness of a wall is the distance between the inner and outer faces. This thickness shall be measured with a steel scale graduated to read directly to 1-16 inch.

Caps or crowns and mouldings, if provided, must be formed and attached to bodies as required in the Specifications.

The inspector will not accept for labeling storage receptacles having single doors mounted on bodies having an inside width greater than the specifications permit to be equipped with a single door.

The inspector will accept for labeling only such storage receptacles as have bodies provided with the special features required in the Specifications.

Heat Insulation. The inspector will not accept for labeling, storage receptacles having walls of bodies or doors insulated with heat-insulating materials other than those given in the Specifications.

The inspector will not accept for labeling, storage receptacles having walls of bodies or doors insulated with other thicknesses of the heat insulating materials than those given in the Specifications. Thicknesses shall be measured with a steel scale graduated to read directly to 1-64 inch.

The inspector will not accept for labeling, storage receptacles having heat-insulating materials disposed within any walls of the bodies or doors in a manner other than is given in the Specifications.

Storage receptacles employing block insulation must not contain more than one (1) broken block in every five (5). All broken blocks used to be carefully cemented together under pressure. Pressure to be maintained until cement is dry. It is preferred that the joint is held by wiring or staples in addition to the cement. No two (2) broken cemented blocks in any wall of the safe to be adjacent.

The inspector will not accept for labeling, storage receptacles in which the heat-insulating materials are held in place in a manner other than that given in the Specifications.

At quarterly intervals, or oftener, when requested by the Laboratories, the inspector will forward samples of all types of insulating material used in Standard safes for analysis and check tests, to see that materials used is the same as that originally submitted.

Hardware. *Hinges.* The inspector will not accept for labeling, storage receptacles equipped with hinges (including hinge pins) made of materials or of a design other than is given in the Specifications.

The inspector will not accept for labeling, storage receptacles having doors mounted to bodies with a lesser number of hinges than is required in the Specifications, or with top and bottom hinges located a greater distance from the ends of the outside face of the door than is specified.

The inspector will not accept for labeling, storage receptacles equipped with hinges which are secured to bodies or doors in a manner other than that given in the Specifications.

Bolting Mechanism. The inspector will not accept for labeling, storage receptacles having doors equipped with bolt bars made of materials or of a design other than that given in the Specifications.

The inspector will not accept for labeling, storage receptacles having doors equipped with bolt bars operated by a mechanism made of materials or of a design other than that given in the Specifications. This will require that the number of bolt bars and their disposition with respect to the door edges will be as given in the Specifications.

The inspector will not accept for labeling, storage receptacles having doors equipped with bolt bars secured to operating mechanisms or with operating mechanisms secured to doors in a manner other than that given in the Specifications.

The inspector will not accept for labeling, storage receptacles having doors equipped with bolt bars which project less than ¾-inch when the bolt bars are thrown as far as the operating mechanism will permit.

Locks. Combination or key locks, if supplied, must be in addition to the latching mechanisms and should be of the design and be attached to doors as given in the Specifications.

Casters. The inspector will not accept for labeling, storage receptacles having bodies equipped with casters made of materials or of a design other than that given in the Specifications.

The inspector will not accept for labeling, storage receptacles having bodies equipped with a lesser number of casters than is required by the Specifications.

Finish. The metal parts on the interior and exterior of storage receptacles must be painted or enameled.

Interior Fittings. Supports for shelving, partitions, etc., if supplied, must be made and secured to interiors of storage receptacles as specified.

Workmanship Great care must be taken to see that all joints at edges of slabs or layers of heat insulating material are tight.

The fit between several sections of the inner shell must be snug and the crack, if any, between the sections uniformly narrow.

All riveting and welding operations must be effectively and properly done.

The latches must operate readily without binding when the doors are in closed position.

It should not be possible to rattle the doors when they are in closed position and the doors latched.

The gap between the outside front face of the body and the outside front faces of the doors and at meeting edges of doors in pairs should be uniformly narrow. Width of gap between doors will usually average about 1-16-inch but should not be greater than 3-32-inch at top and sides nor more than ⅛-inch at bottom.

The metal of the tops of the tongues and bottoms of the grooves of the doors should come as nearly in contact with the bottom of the grooves and the tops of the tongues respectively of the body as is practical. The bottoms of the grooves may be filled with asbestos strips glued in place for the full lengths of the grooves when necessary to accomplish this result. The width of the gap between tongues and grooves should be such that it will not be possible to draw a strip of cotton duck 1-32-inch thick through the door crack nor to readily draw a strip of cotton duck 1-64-inch thick through the crack when the doors are closed.

Markings. Each storage receptacle must be marked with the name or trade-mark of the manufacturer.

Labels. The inspector will see that the labels of a given class (*i.e.* Insulated Cabinet or Safes) are used only on material given that classification in the Specifications.

Manufacturers are urged to use the labels in the consecutive order of their serial numbers so far as is possible, and the inspector shall call attention to a failure to follow practice.

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